sat-nms RMC

Radiometer Controller

User Manual

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1 Introduction

The ***sat-nms*** Radiometer Controller (RMC) is a controller for radiometers. It is not only for use as core module for new radiometers in any frequency band, but also to upgrade existing radiometers. It was developed by SatService GmbH including a highly linear ***sat-nms*** Radiometer Detector (RMD) for the detection of the noise signal in any IF band between 50 and 2000MHz.

The chosen radiometer concept provides high stability and measuring accuracy and easy and flexible operation due to operator friendly user interface.

The radiometer type implemented is noise balancing / noise injection. In addition to that the software includes all other additional functions necessary for a radiometer, for example control functionality for azimuth and elevation of the radiometer antenna. This allows automatic tip curve calibration and automatic calibration with a cold-load via ***sat-nms*** RMC. Also the complete high precision temperature control of the feed box, including the microwave and IF receiving system, is performed via the radiometer controller.

Like any equipment belonging to the ***sat-nms*** family, the radiometer controller provides an Ethernet TCP/IP interface. All measurement results and the monitoring parameters are available via HTTP Web Interface and can be monitored and controlled from remote IOT software either via HTTP get functions or via RS232 interface. The controller includes a compact flash card of 2GB for data logging purposes and allows download of data via FTP.

This document is the user manual provided with the ***sat-nms*** RMC. It contains all necessary information how to install, setup and operate the radiometer. The user manual is available as a printed document and for on-line reading on the radiometer itself as well.

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The paragraphs below give a short overview to the contents of the documentation. A subset of this documentation is stored on the device itself, the complete documentation is available on the ***sat-nms*** documentation CD and at www.satnms.com.

- Installation: The installation description is available at the printed version of the manual only. This is due to memory restrictions of the radiometer. Look at http://www.satnms.com/doc/html/radiometer/ for a full version of this manual.
- Operation: The ***sat-nms*** RMC is operated using a standard web browser like the Internet-Explorer on MS Windows based computers. The user interface design is straight forward and clearly structured. Operating the ***sat-nms*** RMC is mostly self-explanatory. Nevertheless, the 'Operation' chapter outlines the map of web pages which make up the ***sat-nms*** RMC user interface and elaborately describes the meaning of each alterable parameter.
- Remote Control: The radiometer provides a versatile remote control interface. A monitoring & control software may fully operate the radiometer either through a TCP/IP network connection or through the RS232 interface of the radiometer. This chapter describes the communication protocol used for remote control and lists all parameters accessible through the remote interface.
- Theory of Operation: For a detailed description please refer to the ***sat-nms*** documentation CD or www.satnms.com/doc
- Specifications: For a detailed description please refer to the ***sat-nms*** documentation CD or www.satnms.com/doc

Support and Assistance

If you need any assistance regarding our radiometer, don't hesitate to contact us. We would be pleased to help you by answering your questions.

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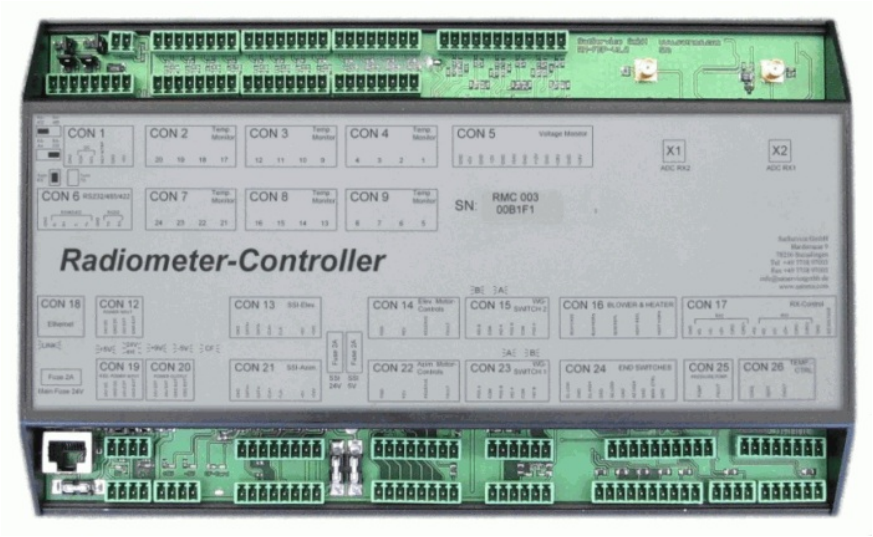
2 Installation

This chapter describes how to install the ***sat-nms*** Radiometer Controller (RMC). You find a guide how to connect, configure and mechanically mount the RMC below.



Before you start, please first read the Safety Instructions chapter below. It contains some important recommendations to prevent damage from the RMC.

Then, we strongly recommend to do a first setup of the RMC on a lab desk before installing it at it's final location. This is mainly for the following reason:

To setup the RMC IP parameters, the PC used for configuring and the RMC must either be connected to the same Ethernet hub or must be connected directly with a crossover cable. The initialization program does not work through routers or intelligent network switches.

Hence, the typical sequence of tasks when putting a ***sat-nms*** RMC outdoor module into operation is as follows:

1. Read the chapter Safety Instructions.
2. Set the RMC IP address.
3. Mechanical mount the RMC.
4. Connect the RMC at its destination environment. Finally connect the power supply and the Ethernet network.

2.1 Safety Instructions

Failure to observe all Warnings and Cautions may result in personnel injury and/or equipment damage not covered by the warranty.

- Follow standard Electrostatic Discharge (ESD) procedures when handling an ***sat-nms*** RMC.
- Select and apply the appropriate 24V D/C voltage according to the data sheet before connecting power.
- Before connecting the ***sat-nms*** RMC to other devices, ensure that these devices can handle the voltage provided by ***sat-nms*** RMC.
- The ***sat-nms*** RMC can be damaged if the input voltage is higher than the specified maximum value.
- Don’t connect a heater without the corresponding Temperature-Sensor. If you don’t connect a Temperature-Sensor, the Temperature regulation in the ***sat-nms*** RMC is going to switch on the heater permanently until the regarding temperature-switch turn off the heater.
- Move an antenna only with connected end switches.

- In case of a failure do not open the ***sat-nms*** RMC enclosure, you will lose warranty. Call SatService GmbH for an RMA number.
- Observe normal safety precautions when operating, servicing, and troubleshooting this equipment.
- Take standard safety precautions with hand and/or power tools.

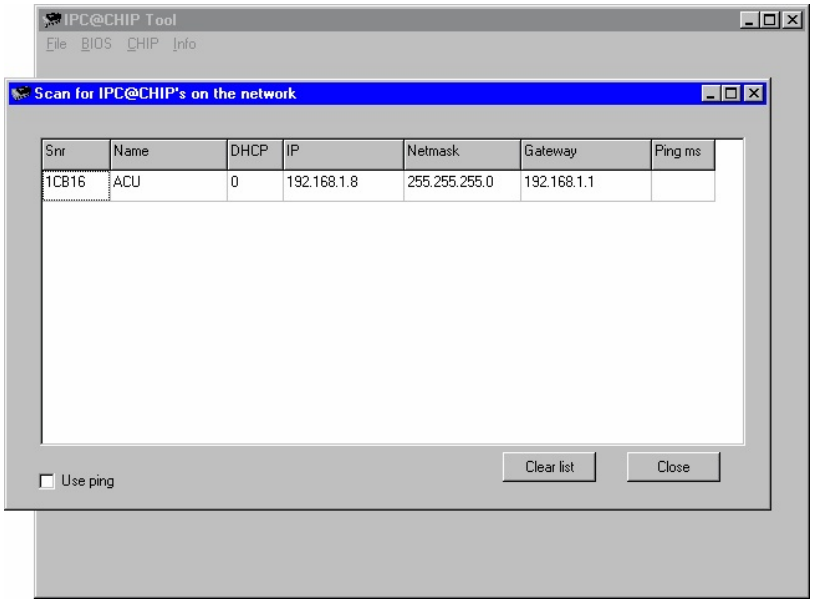
2.2 Setting the IP Address

Before you can operate the RMC, you need to set the RMC's IP address. There is a special configuration program on the documentation CD shipping with the RMC for this purpose. We recommend configuring the RMC TCP/IP settings before you install the RMC at its final place. To configure the RMC, the following equipment is required:

- The ***sat-nms*** RMC outdoor module itself.
- A 24V D/C power supply.
- A Computer running a Microsoft Windows operating system equipped with CD-ROM drive and Ethernet network card.
- A CAT5 crossover network cable or a Ethernet hub and standard network cables to connect the RMC and the computer.
- The CD-ROM shipping with the ***sat-nms*** RMC.

Setting the RMC IP parameters now is easily done within a few minutes.

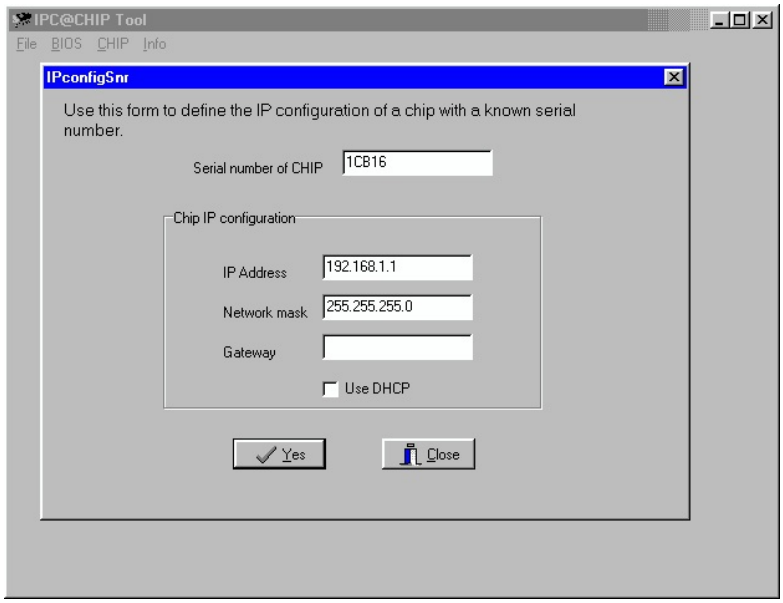
1. First install a network cable between the RMC and your computer. If you have a crossover cable available, this is very easy: simply put the cable into the network connectors of computer and RMC. Without a crossover cable, you need to connect both, the computer and the RMC to the same network hub using two standard network cables. It is essential, that the computer and the RMC are connected to the same network segment, the configuration program is not able to find the RMC through routers or network switches.
2. Now power on your computer and connect the RMC to the 24V D/C supply.
3. Insert the CD-ROM into the computer's drive and inspect its contents through the 'My Computer' icon on your desktop. Double-click to the 'ChipTool.exe' program in the 'ChipTool' directory.
4. When the ChipTool program is running, type CTRL+F to make the program search the RMC. The program shows a list containing at least one entry describing the actual network parameters of the RMC.



5. The serial number shown in the first column of the list, must match the serial number printed on the RMC enclosure. If the list stays empty, the RMC is not connected properly. If there are more entries in

the list, the configuration program has found other devices in this network segment which use the same technology.

6. Now type CTRL+I to open the IP configuration window of the program. In this form enter the RMC serial number, it's new IP address and network mask. If the RMC later shall be operated through a router, enter the address of the router on the gateway field, otherwise leave this field blanc. Be sure, that the 'DHCP' mark is unchecked. Finally click to the 'Yes' button to set the new parameters at the RMC.



Now the IP configuration of the RMC is completed. You may finally want to test if the RMC is reachable now. Start your web browser and type the RMC IP address into the URL field of the browser. The RMC should reply with its main page, provided that the RMC and your computer are configured for the same subnet.

2.3 Connecting the RMC

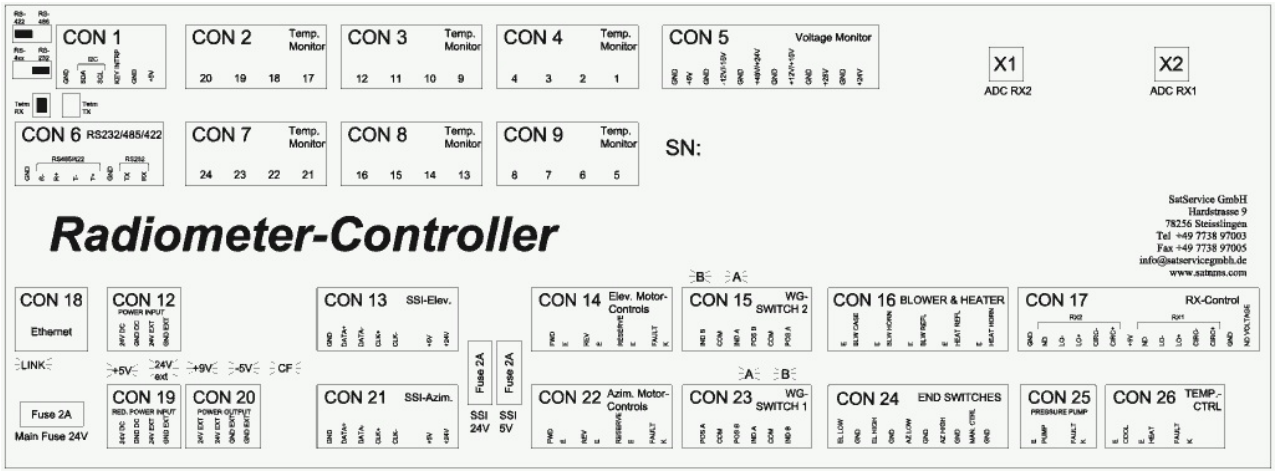
The ***sat-nms*** RMC provides a lot of input/output signals. They all are described in the following chapters. Some applications do not require all ports of the RMC to be cabled.

When connecting and configuring antenna control unit (position sensors and motor drivers), the following sequence of items is recommended:

1. Connect the position sensor, but not the motor driver.
2. Configure the RMC for the correct type of position sensor.
3. Move the antenna a small amount in both directions (you need to command the motor driver directly, e.g. using bridge circuits), verify that the angle changes in the right direction.
4. Enter a calibration offset which lets the RMC show an angle which matches the (roughly) estimated position of the antenna.
5. Now connect the motor driver to the RMC.
6. At the 'Test' page, activate the motor driver outputs for a short time; verify that the antenna moves as expected.

2.3.1 Connector Layout

Below the connector layout of the ***sat-nms*** RMC is shown. Except the network connector which is a standard 10-Base-T Ethernet socket, all connectors are Phoenix Contact Combicon plugs / clamps. Pin 1 of each connector is the right-most if you look at the screws of the connector.



2.3.2 RMC Pin Descriptions

CON1 I2C/Key Interrupt

CON1 is the connector to the on-board I2C-Bus and a Key Interrupt input. This port is to connect an external Handheld. Actually this connector is not used and cabling is not required.

pin	*signal*	*description*	*type*
1	+5V	Power supply	OUT
2	GND	Power supply	
3	Key Interrupt	TTL-level	IN
4	SCL	I2C-bus	I/O
5	SDA	I2C-bus	I/O
6	GND	Signal ground	

CON2 Temperature Monitor

CON2 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open. But be careful, if you select two or three RX-Channels in the software, you have to connect at least the temperature-sensor for the RX 2 reference load because of the RMC temperature control.

pin	*signal*	*description*	*type*
1	TEMP 17 out	RX 2 reference load	OUT
2	TEMP 17 in		IN
3	TEMP 18 out	RX 2 noise source	OUT
4	TEMP 18 in		IN
5	TEMP 19 out	RX 2 peltier-block	OUT
6	TEMP 19 in		IN
7	TEMP 20 out	RX 2 cold-load	OUT
8	TEMP 20 in		IN

CON3 Temperature Monitor

CON3 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open. But be careful, if you use a reflector heater. Here you have to connect at least the reflector heater box temperature-sensor because of the RMC temperature control.

pin	*signal*	*description*	*type*
1	TEMP 9 out	RX 2 reference load	OUT

2	TEMP 9 in		IN
3	TEMP 10 out	RX 2 noise source	OUT
4	TEMP 10 in		IN
5	TEMP 11 out	RX 2 peltier-block	OUT
6	TEMP 11 in		IN
7	TEMP 12 out	RX 2 cold-load	OUT
8	TEMP 12 in in		IN

CON4 Temperature Monitor

CON4 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open. But be careful, you have to connect at least the temperature-sensor for the RX 1 reference load because of the RMC temperature control.

pin	*signal*	*description*	*type*
1	TEMP 1 out	RX 1 reference load	OUT
2	TEMP 1 in		IN
3	TEMP 2 out	RX 1 noise source	OUT
4	TEMP 2 in		IN
5	TEMP 3 out	RX 1 peltier-block	OUT
6	TEMP 3 in		IN
7	TEMP 4 out	RX 1 cold-load	OUT
8	TEMP 4 in		IN

CON7 Temperature Monitor

CON7 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open.

pin	*signal*	*description*	*type*
1	TEMP 21 out	RX 2 waveguide to cold-load	OUT
2	TEMP 21 in		IN
3	TEMP 22 out	RX 2 test-port to cold-load	OUT
4	TEMP 22 in		IN
5	TEMP 23 out	RX 2 waveguide-switch and coupler	OUT
6	TEMP 23 in		IN
7	TEMP 24 out	RX 1 cold-load	OUT
8	TEMP 24 in		IN

CON8 Temperature Monitor

CON8 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open. But be careful, if you have connected a heater for feed-horn or for reflector, connect these temperature-sensors because of the RMC temperature control.

pin	*signal*	*description*	*type*
1	TEMP 13 out	Feed-horn	OUT
2	TEMP 13 in		IN
3	TEMP 14 out	Reflector	OUT
4	TEMP 14 in		IN
5	TEMP 15 out	RX 2 waveguide-switch and coupler	OUT
6	TEMP 15 in		IN
7	TEMP 16 out		OUT

8	TEMP 16 in		IN

CON9 Temperature Monitor

CON9 provides four inputs for NTC-Temperature-Sensors. Connect only the temperature-sensor which belongs to the described measurement point. This is necessary for a correct function of the RMC. If you don't need a measurement point, leave it open.

pin	*signal*	*description*	*type*
1	TEMP 5 out	RX 1 waveguide to cold-load	OUT
2	TEMP 5 in		IN
3	TEMP 6 out	RX 1 test-port to cold-load	OUT
4	TEMP 6 in		IN
5	TEMP 7 out	RX 1 waveguide-switch and coupler	OUT
6	TEMP 7 in		IN
7	TEMP 8 out	CPU	OUT
8	TEMP 8 in		IN

CON5 DC Voltage Monitor

CON 5 provides a DC Voltage Monitor for all necessary voltages a radiometer need. Normally all monitored voltages are needed to operate a radiometer and every input must not be unconnected.

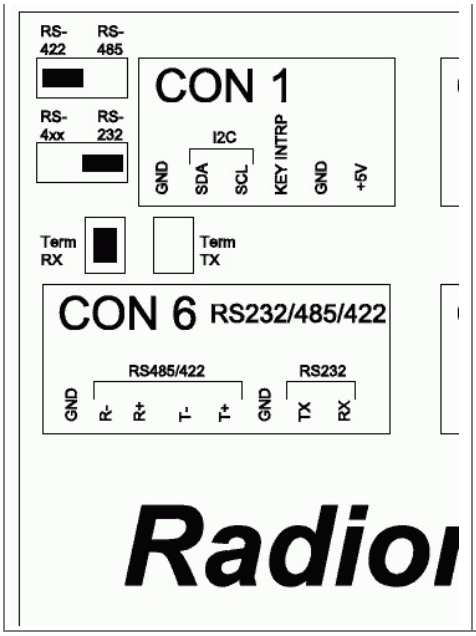
pin	*signal*	*description*	*type*
1	+24V ext	Limits +25V/+21V	IN
2	GND +24V ext		IN
3	+28V	Limits +29V/+25V	IN
4	GND +28V		IN
5	+12V/+15V	Limits +16V/+10V	IN
6	GND +12V/+15V		IN
7	+24V/+48V	Limits +51V/+21V	IN
8	GND +24V/+48V		IN
9	-12V/-15V	Limits -16V/-10V	IN
10	GND -12V/-15V		IN
11	+5V	Limits +5,5V/+4,4V	IN
12	GND +5V		IN

CON6 Serial Interfaces

The RMC owns one serial interfaces to control the RMC from remote where the TCP/IP remote control is not usable. This interface may be configured to work as a RS232 or RS485 2-wire mode/RS422 4-wire mode interface by jumpers inside the RMC.

pin	*signal*	*description*	*type*
1	RS232 TX	RS232 for remote control	OUT
2	RS232 RX	RS232 for remote control	IN
3	GND		
4	RS485/422 TX+	RS485/RS422 for remote control	IN
5	RS485/422 TX-	RS485/RS422 for remote control	OUT
6	RS485/422 RX+	RS485/RS422 for remote control	IN
7	RS485/422 RX-	RS485/RS422 for remote control	OUT
8	GND		IN

The RMC is factory preset to use the RS232 interface. To change the interface configuration, set the jumpers on the RMC main board above CON6 according to the illustration below:



Jumper for configuration of serial interface

- There is one jumper to select between RS4xx and RS232 interface driver. Put the jumper to position RS-232 (right) to select the RS232 interface.
- The second jumper switches between the RS422 4-wire mode and RS485 2-wire mode. To select RS485 2-wire mode put the jumper to position RS-485 (right). Use the TX data lines (CON6 Pins 4, 5) in this mode.
- Term RX and Term TX activate 100 Ohms termination resistors between the RS422 data lines. The lines are terminated if the jumper is set.

X1/X2 DC-Voltage input from Radiometer Detector

X1 and X2 are SMA-connectors for the DC-voltage from the Radiometer Detector. There are two connectors for three RX-channels. Connector X2 is for the channel 1 and connector X1 is for the channel 2 and channel 3. So channel 2 can handle two input signals. The voltage range is between 0V and +5V. Every input has input high impedance and provides a sample&hold filter to improve measurement results. See also chapter Theory of Operation for details.

pin	*signal*	*type*
X1	RX channel 2; 0V…+5V input voltage range	IN

pin	*signal*	*type*
X2	RX channel 1; 0V…+5V input voltage range	IN

CON12 Power Supply

At CON12 the power supply for the RMC itself (pins 1, 2) and fort the external devices must be connected. For operation two different power supplies are needed, one for the RMC itself and one for the external devices like the waveguide-switches or the antenna motor control. Also see chapter Power Supply Cabling for the concept of separate intern / extern power supplies the RMC uses.

pin	*signal*	*description*	*type*
1	+24V RMC	Power supply for the RMC and the position encoders	IN
2	GND RMC		IN
3	+24V EXT	Power supply for waveguide-switches, antenna motor control, end switches, heater and blower control and temperature control	IN
4	GND EXT		IN

CON19 Redundant Power Supply

CON19 is to connect a redundant power supply for the RMC and for the external devices. For a redundant power supply system you have to connect four power supplies.

pin	*signal*	*description*	*type*
1	Red. +24V RMC	Redundant power supply for the RMC and the position encoders	IN
2	Red. GND RMC		IN
3	Red. +24V EXT	Redundant power supply for waveguide-switches, antenna motor control, end switches, heater and blower control and temperature control	IN
4	Red. GND EXT		IN

CON20 Power Output

CON20 provides two clamps to the +24V external voltage rail and two clamps to the GND external voltage rail. This is for a easier external cabling.

pin	*signal*	*description*	*type*
1	+24V EXT	Power Output +24V	IN
2	+24V EXT		IN
3	GND EXT	Power Output GND	IN
4	GND EXT		IN

CON13 SSI Elevation Angle Encoder Interface

Below the pin out of a SSI type angle encoder interface board is shown. The RMC uses this modern high speed serial interface to readout the angle of Elevation (if present). The SSI angle encoder may be powered from the RMC internal power supply. +5V and +24V clamps are provided at the connector. To avoid ground loops, the cable shield should be connected either to pin 1 at the RMC or to the ground at the encoder housing, never at both ends.

pin	*signal*	*description*	*type*
1	GND		OUT
2	SSI-Data+	SSI data+	IN+
3	SSI-Data-	SSI data-	IN-
4	SSI CLK+	SSI clock+	IN+
5	SSI CLK-	SSI clock-	OUT-
6			
7	+5V	encoder power supply	OUT
8	+24V	encoder power supply	IN

CON21 SSI Azimuth Angle Encoder Interface

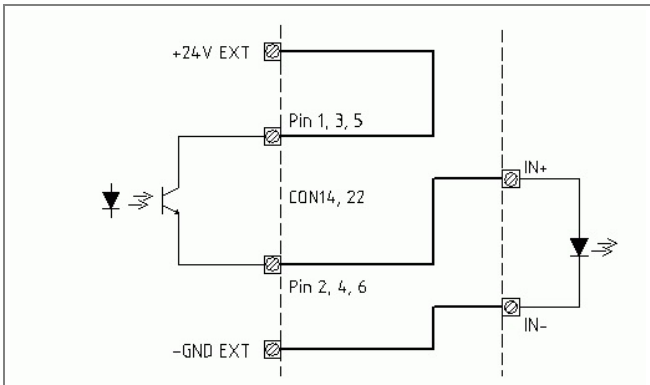
Below the pin out of a SSI type angle encoder interface board is shown. The RMC uses this modern high speed serial interface to readout the angle of Azimuth and (if present). The SSI angle encoder may be powered from the RMC internal power supply. +5V and +24V clamps are provided at the connector. To avoid ground loops, the cable shield should be connected either to pin 1 at the RMC or to the ground at the encoder housing, never at both ends.

pin	*signal*	*description*	*type*
1	GND		OUT
2	SSI-Data+	SSI data+	IN+
3	SSI-Data-	SSI data-	IN-

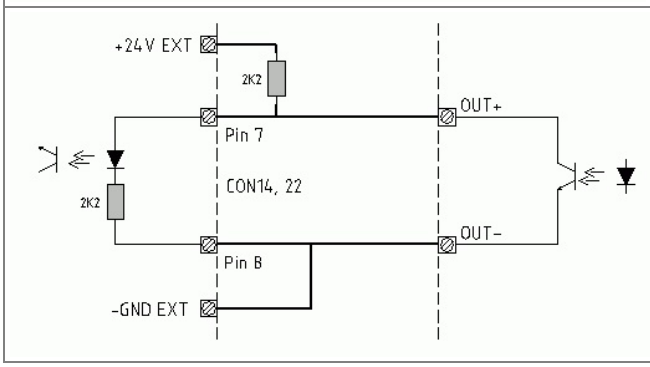
4	SSI CLK+	SSI clock+	IN+
5	SSI CLK-	SSI clock-	OUT-
6			
7	+5V	encoder power supply	OUT
8	+24V	encoder power supply	IN

CON14 Elevation Motor Controls

All signals for motor control are provided as free floating optocoupler inputs / outputs. This gives a maximum of flexibility to adapt the cabling to the motor driver units. They probably will combine one end of the control inputs to a common potential. The RMC is capable to control motor drivers with different polarity concepts.



Example for wiring the motor drive signals

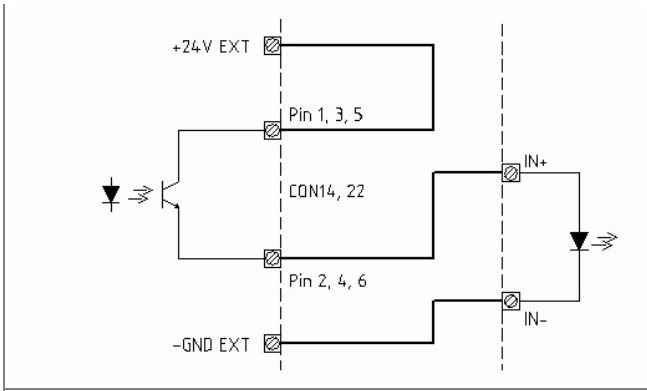


Example for wiring the motor status signals

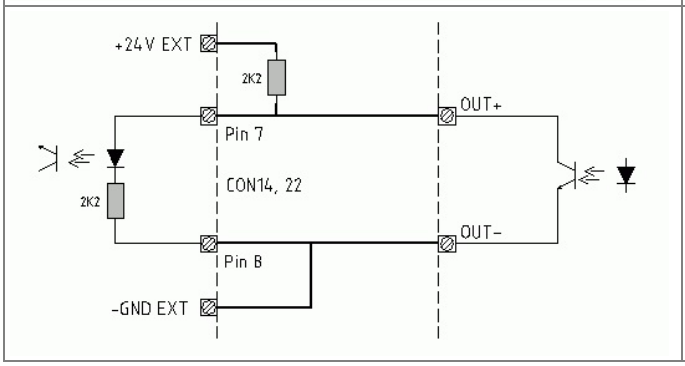
pin	*signal*	*description*	*type*
1	EL FWD C	Motor forward	OUT+
2	EL FWD C		OUT-
3	EL REV C	Motor rewind	OUT+
4	EL REV E		OUT-
5	EL RESERVE C	Reserve	OUT+
6	EL RESERVE E		OUT-
7	EL FAULT A	Fault	IN+
8	EL FAULT K		IN-

CON22 Azimuth Motor Controls

All signals for motor control are provided as free floating optocoupler inputs / outputs. This gives a maximum of flexibility to adapt the cabling to the motor driver units. They probably will combine one end of the control inputs to a common potential. The RMC is capable to control motor drivers with different polarity concepts.



Example for wiring the motor drive signals



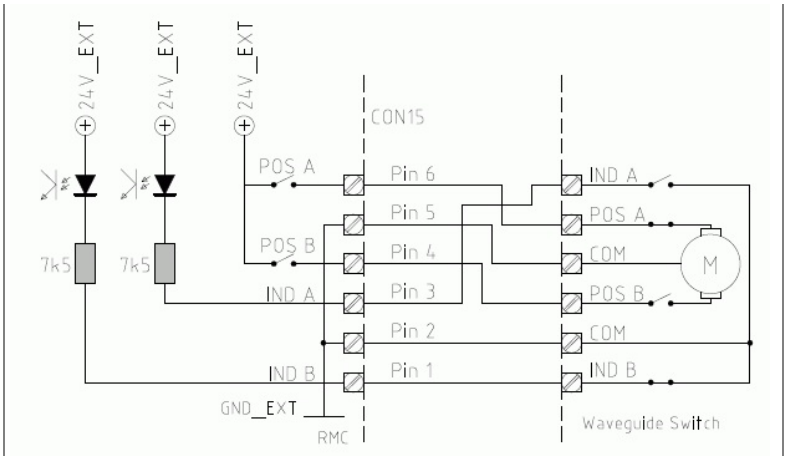
Example for wiring the motor status signals

pin	*signal*	*description*	*type*
1	AZ FWD C	Motor forward	OUT+
2	AZ FWD C		OUT-
3	AZ REV C	Motor rewind	OUT+
4	AZ REV E		OUT-
5	AZ RESERVE C	Reserve	OUT+
6	AZ RESERVE E		OUT-
7	AZ FAULT A	Fault	IN+
8	AZ FAULT K		IN-

CON15 Waveguide-switch RX2

At CON15 the RMC provides a connection for a waveguide switch related to RX 2.

pin	*signal*	*description*	*type*
1	IND B	Indication Pos B	IN
2	COM IND		IN
3	IND A	Indication Pos A	IN
4	POS B	Position B	OUT
5	COM POS		OUT
6	POS A	Position A	OUT

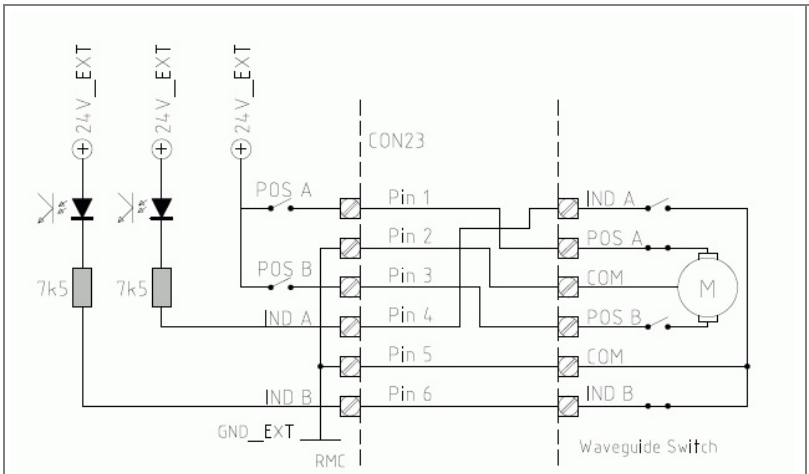


Example for wiring a waveguide switch

CON23 Waveguide-switch RX1

At CON15 the RMC provides a connection for a waveguide switch related to RX 1.

pin	*signal*	*description*	*type*
1	POS A	Position A	OUT
2	COM POS		OUT
3	POS B	Position B	OUT
4	IND A	Indication Pos A	IN
5	COM POS		IN
6	IND B	Indication Pos B	IN



Example for wiring a waveguide switch

CON16 Blower and Heater

CON16 provide some outputs to control blowers and heaters in a radiometer. All signals are free floating optocoupler outputs for DC. This gives a maximum of flexibility to adapt the cabling to different blowers and heaters. For a connection with external devices please also take a look also to Elevation Motor Wiring.

pin	*signal*	*description*	*type*
1	BLW CASE E		OUT
2	BLW CASE C	Blower for the radiometer case	OUT
3	BLW HORN E		OUT
4	BLW HORN C	Blower for the horn antenna	OUT

5	BLW REFL E		OUT
6	BLW REFL C	Blower for reflector	OUT
7	HEAT REFL E		OUT
8	HEAT REFL C	Heater for reflector	OUT
9	HEAT HORN E		OUT
10	HEAT HORN C	Heater for horn antenna	OUT

CON17 RX-Control

CON17 provide some outputs to control the components in a radiometer receiver (circulator, noise-diode, LO). The output voltage is TTL-compatible (0/5V). There are two equal sets of output signals.

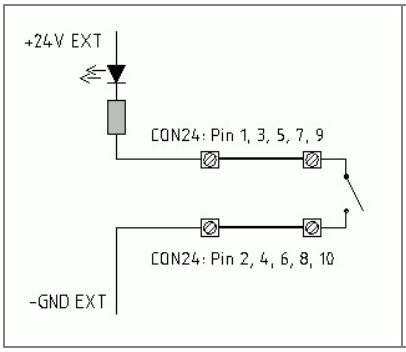
pin	*signal*	*description*	*type*
1	GND		OUT
2	ND RX2	Noise-diode control receiver 2	OUT
3	LO- RX2	Local oscillator control receiver 2	OUT
4	LO+ RX2	Local oscillator control receiver 2	OUT
5	CIRC- RX2	Circulator control receiver 2	OUT
6	CIRC+ RX2	Circulator control receiver 2	OUT
7	+5V	Supply Voltage	OUT
8	ND RX1	Noise-diode control receiver 1	OUT
9	LO- RX1	Local oscillator control receiver 1	OUT
10	LO+ RX1	Local oscillator control receiver 1	OUT
11	CIRC- RX1	Circulator control receiver 1	OUT
12	CIRC+ RX1	Circulator control receiver 1	OUT
13	GND		OUT
14	ND VOLTAGE	Voltage input for the two noise-diodes	OUT

Pin 14 is an input for the noise-diode voltage. If you use a noise-diode with +28V you have to connect an external voltage here. If you use a noise-diode with +5V you can connect pin 14 to pin 7. However, for a correct function of the noise-diode control signal you have to connect a voltage.

CON24 End Switches

CON24 provides the end switches for the antenna control unit. The end switch inputs internally are connected to the external 24V / GND rails. The switches are connected directly to the input pairs without any external ground or supply cabling. The RMC treats closed contact as OK; contacts have to be opened to indicate the 'limit reached' condition.

There is also the feedback input for manual control with a handheld. The RMC treats closed contact as handheld connected.



Example for wiring the limit switches and the handheld

pin	*signal*	*description*	*type*
1	EL LOW	Lower limit Elevation	IN
2	GND EXT		IN

3	EL HIGH	Upper limit Elevation	IN
4	GND EXT		IN
5	AZ LOW	Azimuth left limit (view from behind antenna)	IN
6	GND EXT		IN
7	AZ HIGH	Azimuth right limit (view from behind antenna)	IN
8	GND EXT		IN
9	MNL CTRL	Manual Control feedback	IN
10	GND EXT		IN

CON25 Pressure Pump

CON25 provides a input and a output to connect a pressure pump. All signals are free floating optocoupler outputs for DC. This gives a maximum of flexibility to adapt the cabling to different pressure pumps. Actually you can switch on the pump and read out a fault.

pin	*signal*	*description*	*type*
1	PUMP E		OUT
2	PUMP C	Switch on Pressure Pump	OUT
3	FAULT A	Fault feedback	IN
4	FAULT K		IN

CON26 Temp.-Control

CON26 provides outputs to control the temperature in the receiver case. All signals are free floating optocoupler outputs for DC. This gives a maximum of flexibility. For a connection with external devices please also take a look also to Elevation Motor Wiring.

pin	*signal*	*description*	*type*
1	COOL E		OUT
2	COOL C	Cool Signal	OUT
3	HEAT E		OUT
4	HEAT C	Heat Signal	OUT
5	FAULT A	Fault Feedback	IN
6	FAULT K		IN

2.3.3 Power Supply Cabling

The RMC uses optocoupler interfaces to the motor drivers, end switches, waveguide-switches, blowers and heaters, pressure pump and to the temperature control. This permits to use a complete separate power supply with a separate ground for these circuits (+24V EXT, GND EXT).

To simplify the cabling of these circuits, the RMC distributes the external 24V and GND lines through a separate clamp (CON20).

2.3.4 Mechanical Installation

The ***sat-nms*** RMC enclosure is DIN rail mountable. Hence simply snap the ***sat-nms*** RMC on to the rail to fix it. For plain wall mount, fix a 100 mm piece of DIN rail at the wall with at least two screws and lock the ***sat-nms*** RMC on this.

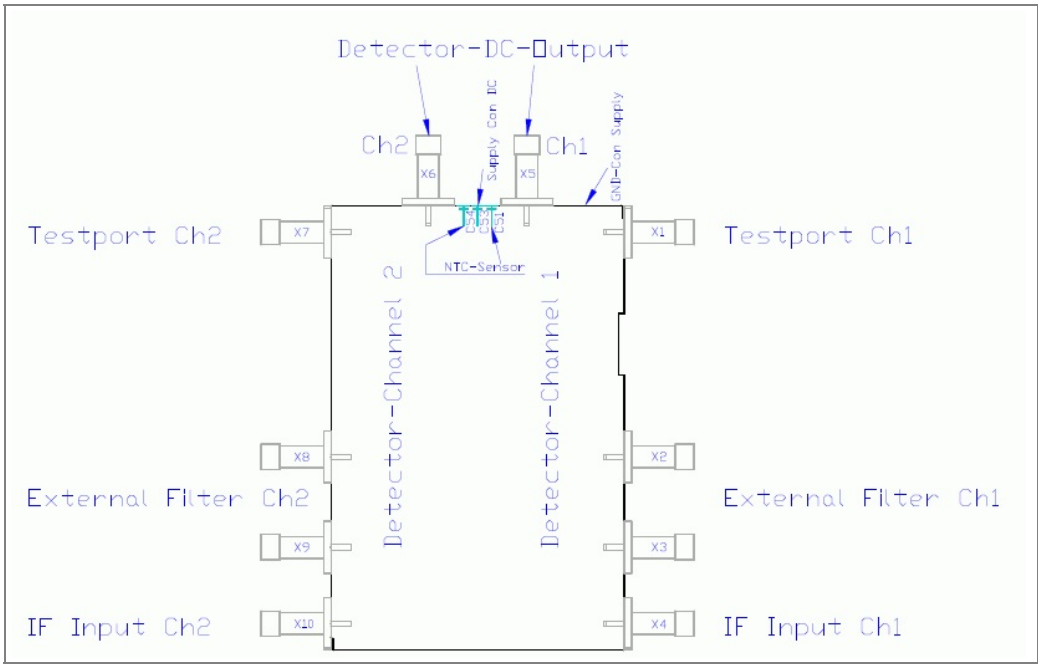
When planning the mechanical installation of the ***sat-nms*** RMC, please consider that cables to the ***sat-nms*** RMC have to be fixed o the upper and the underside. So you need some space and something to fix the cables.

2.4 Connecting the RMD

The ***sat-nms*** RMD is a separate device. It can be mounted at different positions than the RMC. The RMD provides two detector channels. The connectors are described in the following chapters.

2.4.1 Connector Layout

Below the connector layout of the ***sat-nms*** RMD is shown. For the IF inputs, external filters and for the dc outputs are all connectors SMA. This provides a maximum resistance against interferer. The detector is shown from top view. In this position you can read the label correct.



RMD Connector Layout

2.4.2 RMD Pin Descriptions

X4 IF Input Channel 1

X4 is the input connector for the IF Channel 1.

pin	*description*	*type*
X4	IF input channel 1; DC blocked ; 50Ohm SMA connector	IN

X3, X2 External Filter Channel 1

X3 and X2 are connectors for an external filter. There is a 70MHz IF filter on-board. If you don't use this frequency, you can connect an external filter. But be careful, you have to change the signal way on the PCB. There are two capacitors, which have to solder in direction of the SMA connectors. The detector is designed broadband. You can use it from 50MHz to 2000MHz.

pin	*description*	*type*
X3	External filter output; 50Ohm SMA female connector	OUT
X2	External filter input; 50Ohm SMA female connector	IN

X1 Test-port Channel 1

X1 is a test-port output for channel 1.

pin	*description*	*type*
X1	IF input channel 1; DC blocked; 50Ohm SMA female connector	OUT

X5 DC-Output Channel 1

X5 is the output port for the rectified IF signal.

pin	*description*	*type*
X5	DC output; 0…5V; SMA female connector	OUT

X10 IF Input Channel 2

X10 is the input connector for the IF Channel 2.

pin	*description*	*type*
X10	IF input channel 2; DC blocked ; 50Ohm SMA female connector	OUT

X9, X8 External Filter Channel 2

X9 and X8 are connectors for an external filter. There is a 70MHz IF filter on-board. If you don't use this frequency, you can connect an external filter. But be careful, you have to change the signal way on the PCB. There are two capacitors, which have to solder in direction of the SMA connectors. The detector is designed broadband. You can use it from 50MHz to 2000MHz.

pin	*description*	*type*
X9	External filter output; 50Ohm SMA female connector	OUT
X8	External filter input; 50Ohm SMA female connector	IN

X1 Test-port Channel 1

X4 is a test-port output for channel 1.

pin	*description*	*type*
X10	IF input channel 1; DC blocked; 50Ohm SMA female connector	IN

X6 DC-Output Channel 2

X6 is the output port for the rectified IF signal.

pin	*description*	*type*
X6	DC output; 0…5V; SMA female connector	OUT

Power Supply

C53 is a through hole capacitors for the positive power supply. The GND connector is a solder tag near X5.

pin	*description*	*type*
	Positive power supply (C53)	IN
	GND power supply	IN

Temperature Sensor

C51 and C54 are through hole capacitors for an internal temperature sensor. This sensor is a NTC resistor on the PCB.

pin	*description*	*type*
	Temperature sensor (C51)	
	Temperature sensor (C54)	

2.4.3 Power Supply

The RMD only need one input voltage between 12V…24V. On-board is a conditioning for all needed voltages. All SMA connectors, the PCB and the case are at the same ground plane.

2.4.4 Mechanical Installation

The ***sat-nms*** RMD enclosure is DIN rail mountable. Hence simply snap the ***sat-nms*** RMD on to the rail to fix it.

2.5 Format Compact Flash Card

The Radiometer Controller stores on the compact flash card every second the measured sky temperature from each channel. There are for every day one file. The Software opens this file and writes in it. After one day the software close this file and open the next file. After approximate 2 years the oldest file will be overwritten. For this the compact flash card have to be formated with a SatService tool. This tool is

provided on the documentation CD or direct at SatService GmbH.

The tool formats the compact flash card with simple text files, for each day one and filled with zeros. The name format of the files is:

yyyymmdd.txt.

Insight the files the format for every line is:

20090814121723 11.7 15.2 19.6

or generally

yyyymmddhhmmss channel1 channel2 channel3.

You need a PC with installed a Java 6, a compact flash card reader and a compact flash card with 2GB FAT-system.

1. Open a command window and go to the directory with the java class file.
2. Connect the compact flash card reader with the compact flash card. Check the device character and if the card is empty.
3. Type:

   java RadiometerFormatCF X:

   (X is the device character)

4. The format program starts and show the status in the command window

3 Operation

The ***sat-nms*** radiometer is designed to be controlled over a network link using a standard web browser. This means in practice, that the user interface to the radiometer appears in your browser window after you type in the radiometer's IP address in the address field of the browser program.

Operating the radiometer is mostly self-explanatory.

3.1 The Web-based User Interface

After having connected the radiometer to a power supply and set the radiometers IP address, you can access the radiometer's user interface. To do this, start your favorite web browser program (Internet Explorer, Mozilla Firefox, Opera or what else program you prefer). At the address field, where you normally enter the URL of a web page you want to see, type in the IP address of the ***sat-nms*** radiometer you want to control.

The radiometer shows a web page consisting of a navigation bar at the left side of the browser window and the actual readings of the radiometer in the main part of the window. The readings automatically refresh once a second.

The navigation bar at the left contains eight buttons which build the radiometer's main menu:

Reading	This button switches back to the radiometers main page you already see when you connect to the radiometer. This page displays the actual readings of the radiometer.
Settings	By clicking to this button you switch to the 'Settings' page where you can view and change the common operational settings of the radiometer like frequency or bandwidth.
Presets	By clicking to this button you switch to the 'Presets' page. The radiometer is capable to store up to 20 presets of operational parameters.
Calibration	The calibration constants used by the radiometer are managed with this page. Also the tip-curve and cold-load calibration procedures are started here.
Test	The test page gives some information about the hardware interfaces between the radiometer controller and the front end electronics. This page is intended to be used for testing and installation tasks only.
Setup	This button switches to the 'Setup' page which lets you inspect or change less common parameters which usually are set only once to adapt the radiometer to it's working environment.
Info	After a mouse click to this button, the radiometer shows a table with information like the serial number of the device or the revision ID and compilation date of the software.
Help	Clicking to this button shows the on-line version of this user manual

3.2 Displayed Readings

The 'Readings' page is the main page of the radiometer which shows the actual measurement values and some important settings. Parameter settings reported here, are for information only. To change a setting switch to the Settings page. The 'Readings' page automatically refreshes once a second (the refresh rate may be set at the Setup page. The table below describes the information shown by this page:

Parameter Name	*Description*
Atm. Temperature	Displays the actually measured atmospheric temperature. If the radiometer is equipped with less than three channels, the readings which are not applicable are shown as '-.--'
Atm. Attenuation	Displays the atmospheric attenuation calculated from the readings in the line above.
Raw Reading	Displays the raw reading sent by the radiometer front-end controller. This reading is an integer number in the range 0..2048, representing the number of noise diode pulses injected to the antenna signal within one second in order to get the same energy than from the reference load. High values stand for a low atmospheric temperature / attenuation.
Antenna	This line shows the actual antenna pointing and some state information about the antenna pointing control. The following applies to both axes (AZ/EL): • The angle displayed is the actual pointing measured by the angular encoder if

	available. If there is no motor control installed for this axis, the value entered at the settings page is displayed here. • MOVING is displayed beside the reading if the motor is on. • HI-LIMIT signals that the antenna is at the hi (upper/right) limit. • LO-LIMIT signals that the antenna is at the low (left) limit. • MANUAL appears at the rightmost column if the control box for the antenna motors is plugged into the radiometer controller.
Summary	The summary fault indicator shows FAULT if at least one fault flag in the radiometer controller is set.
Reference Load Temperature	This field shows the temperature of the channel 1 reference load and a fault indicator if the temperature does not match it's target within the limits.
NTP Time Sync	Shows a fault indicator for the last attempt to synchronize the controller's clock to a NTP server. Shows 'n/a' if the radiometer is not configured to sync it's clock by means of NTP.
CF Card	This indicator reports if the radiometer actually is logging it's readings to compact flash card. If "NOT LOGGING" appears here, either logging is disabled (at the Settings page) or there is a problem with the CF-Card.
Sun Outage	This indicator shows FAULT if the antenna actually looks right to the sun (within some configurable limits) and the readings may be wrong due to this fact. Please note that the antenna pointing as well as the geodetic location of the antenna must be known with a sufficient precision in order to use this feature.
Rain Detect	If the atmospheric temperature measured with channel 1 exceeds a configurable threshold, the radiometer assumes rainfall and switches the feed-horn / reflector blowers on. 'RAIN' indicates this condition.
Environment Temperature	The environment temperature is measured below the outer casing of the radiometer.
Reflector Temperature	The reflector temperature.
Time	The actual time of the radiometer's clock. Beside the time itself, the time of the last synchronization to a reference (either the radiometer's RTC chip or NTP) is shown.

During a the tip-curve or cold-load calibration process, additional information is displayed below or even instead of this table. Please refer to the applicable sections of this document.

3.3 Operational Parameters

The page 'Settings' contains the radiometer's operational parameters. Operational parameters are those which are assumed to be changed more frequently than the installation parameters on the Setup page.

The page displays a table with the parameters actually set. Each parameter value is a hyper-link to a separate page which lets you change this parameter. This parameter change page shows the actual parameter setting either in an entry field or in a drop down box. You may change the parameter to the desired value and then click to the 'Submit' button to pass the changed value to the radiometer. The radiometer automatically returns to the settings page when the parameter has been changed. To cancel a parameter modification you already started, either use the 'Back' button of you web browser or click to the 'Settings' button on navigation bar. Both returns to the settings page without changing the parameter you edited.

The table below lists the settings provided by this page.

Preset Name

Parameter Name	*Description*
Preset name	You can name the actual set of parameters (up to 40 characters). If you store the parameter set as a preset, this name acts as a label for the stored preset in the list.

Antenna Pointing

Parameter Name	*Description*
AZ Target value	The antenna azimuth pointing. If the radiometer is equipped with a motorized azimuth adjustment, entering a new value lets the antenna move to the selected pointing. Pleased

	note, that the radiometer takes no readings while the antenna is moving. **Important Remark:** Even if the radiometer has no motorized azimuth adjustment, you should enter the antenna azimuth direction here as precise as possible. The sun outage detection depends on this value.
EL Target value	The antenna elevation pointing. If the radiometer is equipped with a motorized elevation adjustment, entering a new value lets the antenna move to the selected pointing. Pleased note, that the radiometer takes no readings while the antenna is moving. **Important Remark:** Even if the radiometer has no motorized elevation adjustment, you should enter the antenna elevation direction here as precise as possible. The sun outage detection depends on this value as well as the correction of the amount of ground temperature contributing to the reading.

Antenna Temperature Control

Parameter Name	*Description*
F/H heater mode	Setting this to AUTO enables the heed horn temperature control (a simple on/off thermostat with a hysteresis of 2K). OFF switches the feed-horn heater permanently off.
F/H target temperature	The feed-horn thermostat target temperature.
F/H blower mode	AUTO selects the automatic control of the feed-horn blower, OFF switches the blower permanently off. In AUTO mode, the feed-horn blower is ON if at least one of the following conditions is true: • The feed-horn heater is on • The radiometer detected rainfall (see below) • The feed temperature is higher than the threshold defined below.
F/H blower temp. threshold	If the feed-horn temperature raises above this threshold, this forces the feed-horn blower to be switched on (provided the F/H blower mode is set to AUTO). If there is no other condition active which switches the feed-horn blower on, it will turn off again if the feed-horn temperature falls 2K below the threshold.
F/H blower rain detection	If the atmospheric temperature reading of the first radiometer channel exceeds this limit, the radiometer assumes rainfall. This is indicated at the Reading page and forces the feed-horn and reflector blowers to be on. The 'rain' condition remains true for 3 minutes after the radiometer reading again falls below the limit.
RFL heater mode	Setting this to AUTO enables the reflector temperature control (a simple on/off thermostat with a hysteresis of 2K). OFF switches the reflector heater permanently off.
RFL min. temperature	This is the reflector thermostat target temperature. The reflector heater switches on if the reflector temperature falls below this value - 1K, switches off when if the temperature raises to 1K above the target value.
RFL heater max. temperature	The reflector heater switches off, if the temperature of the heater box itself is above this limit (this protects the heater).
RFL blower mode	AUTO selects the automatic control of the reflector blower, OFF switches the blower permanently off. In AUTO mode, the reflector blower is on if at least one of the following conditions is true: • The reflector heater is on • The radiometer detected rainfall (see above) • The reflector temperature is higher than the threshold defined below.
RFL blower temp. threshold	If the reflector temperature raises above this threshold, this forces the reflector blower to be switched on (provided the RFL blower mode is set to AUTO). If there is no other condition active which switches the reflector blower on, it will turn off again if the reflector temperature falls 2K below the threshold.

Measurement

Parameter Name	*Description*

Averaging time	The base integration time of the radiometer front end is one second. The radiometer is capable to apply an additional averaging to the readings which is configured here. The averaging is a simple FIR filter of the specified length (e.g. 5 seconds averaging time means that the displayed reading is the average of the last five values).
Sun pos. calculation interval	The time interval when the radiometer re-calculates the sun coordinates for the sun outage detection. 30 seconds is a suitable value in most cases.
Sun pos. fault az-diff (+/-)	The radiometer signals a sun outage fault if the calculated sun azimuth and radiometer azimuth differ by less than the value entered here.
Sun pos. fault el-diff (+/-)	The radiometer signals a sun outage fault if the calculated sun elevation and radiometer elevation differ by less than the value entered here.

Miscellaneous

Parameter Name	*Description*
Case blower OFF	(ON/OFF) Switches the blower inside the radiometer case on or off.
Waveguide pressurizer	(ON/OFF) Controls the waveguide pressurizer.
Logging to CF card	(ON/OFF) Controls if the radiometer logs it's readings to a compact flash card.

3.4 Presets

The page 'Presets' gives access to the radiometer's preset memory. The radiometer is capable to remember up to 20 sets of operational parameters which can be easily restored. Managing these memories is done with the 'Presets' page. A preset contains all parameters which are presented at the Settings page.

The 'Presets' page displays a table with all presets actually stored. The preset name set at the time the preset was saved together with the antenna pointing is used a the preset label in the list. By clicking the icons in the table, settings may be stored, recalled or deleted:

Go	If a memory location has stored a preset, the table shows a blue arrow in the 'Go' column of the table. Clicking to this arrow recalls the settings stored for that target and moves the antenna to the stored pointing. The radiometer displays a confirmation dialog before it actually recalls the preset memory. Only if you click to 'Submit' in this dialog, the antenna moves to the stored location and the stored parameters are read.
Save	For each memory location the table shows a floppy disk icon in the 'Save' column. Clicking to this icon saves the actual operational settings to the selected memory location. Again, there is a confirmation dialog page before the data actually is saved.
Delete	Analogous to the 'Save' icon, the table shows an eraser icon in the 'Delete' column. The icons only are shown for the memory locations which are in use. Clicking to the eraser icon clears the selected memory location after a confirmation inquiry.

3.5 Calibration

This page defines the calibration constants used by the radiometer to calculate the atmospheric temperature and attenuation from the raw readings received from the radiometer front-end. It also gives access to the tip curve and cold-load calibration / verification routines built into the radiometer.

WARNING:

> Most of the calibration constants are values which are only valid for the particular radiometer hardware the controller is assigned to. Only change these values if you really know what you are doing.

The page displays a table with the parameters actually set. Each parameter value is a hyper-link to a separate page which lets you change this parameter. This parameter change page shows the actual parameter setting either in an entry field or in a drop down box. You may change the parameter to the desired value and then click to the 'Submit' button to pass the changed value to the radiometer. The radiometer automatically returns to the setup page when the parameter has been changed. To cancel a parameter modification you already started, either use the 'Back' button of you web browser or click to the 'Setup' button on navigation bar. Both returns to the setup page without changing the parameter you edited.

The table below lists the settings provided by this page.

Channel 1/2/3 Calibration Constants

These calibration constants appear three times for each radiometer channel separately.

Parameter Name	*Description*
Noise correction (b)	The basic calibration factor, calibrates the pulse count to atmospheric temperature calculation. The noise correction factor usually is determined by a cold-load calibration. The cold-load calibration procedure built into the radiometer's software sets this value automatically when operator accepts the calibration result.
RX Reflection coeff. (r_ant)	The antenna reflection coefficient (equation 5.6)
Diplexer loss (L_wg1)	The wave guide / diplexer loss (equation 5.8)
W/G & coupler loss (L_wg2)	The waveguide / coupler loss (equation 5.7)
Waveguide loss (L_wg3)	The (external) wave guide loss to the cold-load (equation 5.20)
Waveguide loss (L_wg4)	The (external) wave guide loss to the cold-load (equation 5.19)
Test port W/G loss (L_wg5)	The test-port wave guide loss (equation 5.18)
Feed weight factor (a)	The feed weight factor for correcting the feed horn noise (equations 5.9, 5.10)
Feed loss (L_h)	The feed loss factor (equation 5.9)
Reflector loss (L_rfl)	The reflector loss factor (equation 5.12)
Media temperature	The media temperature used to calculate atmospheric attenuation from temperature.

Misc. Calibration Constants

Parameter Name	*Description*
Ground temperature	The ground temperature
Cosmic temperature	The cosmic temperature
Noise quantum	The noise quantum injected with one pule of the noise diode. (equations 5.5, 5.6)

Reference Load Temperature Control

The behavior of the reference load temperature control has heavy impact on the radiometer calibration and the stability / reproducibility of measurement results. This is the reason why these parameter have been located here rather than at the settings page with the other antenna temperature control parameters.

Parameter Name	*Description*
Ref load target temp.	The target temperature of the reference load. A single channel radiometer compares this value to the reference load 1 temperature, a radiometer with more than one channel the temperature control uses the average of both reference load temperatures as actual value in the control loop.
Ref load loop P-factor	The P-factor of the PI closed loop temperature control.

Ref load loop I-factor	The I-factor of the PI closed loop temperature control.
Temp. diff. fault limit	If the target / actual values of the control loop differ by more than this limit, a reference load temperature control fault is signaled.

Tip Curve Calibration

The settings in this section define the parameters of a tip curve calibration / verification. For a detailed description of the tip curve calibration procedure see section Tip Curve Calibration.

Parameter Name	*Description*
T/C minimum elevation	The minimum elevation angle to be set during the tip curve calibration.
T/C maximum elevation	The maximum elevation angle to be set during the tip curve calibration.
T/C number of steps	The number of (elevation) steps to be done during the tip curve calibration.
T/C measurement delay	The time to wait after moving the antenna to the first measurement sample.
T/C samples to average	The number of measurements sample to average at one elevation setting.
Start tip curve calibration	Clicking to this link lets the radiometer **immediately** start a tip curve measurement.

Cold-Load Calibration

The settings in this section define the parameters of a cold-load calibration / verification. For a detailed description of the cold-load calibration procedure see section Cold-Load Calibration.

Parameter Name	*Description*
C/L channel 1 nominal temp.	Enter the nominal temperature of the cold load here. This value usually is taken from the cold-load's data / calibration sheet. The value may depend on frequency.
C/L channel 2 nominal temp.	Enter the nominal temperature of the cold load here. This value usually is taken from the cold-load's data / calibration sheet. The value may depend on frequency.
C/L channel 3 nominal temp.	Enter the nominal temperature of the cold load here. This value usually is taken from the cold-load's data / calibration sheet. The value may depend on frequency.
C/L samples to average	The number of radiometer readings to be averaged for the calibration.
Switch channel 1 to cold-load	Starts a cold-load calibration for radiometer channel 1.
Switch channel 2/3 to cold-load	Starts a cold-load calibration for radiometer channel 2/3

3.5.1 Tip Curve Calibration

The tip curve calibration measures the atmospheric attenuation at different elevation angles. While lowering the elevation, the atmospheric attenuation rises. From this tip curve an absolute offset in the radiometer reading may be calibrated, the offset gets applied as feed-horn loss if the calibration is accepted by the operator. There should be constant "clear sky" conditions during this test to get reasonable results. If the elevation axis is motorised the RMC move the antenna automatically. If there is no motorised axis the user have to move the antenna manual.

The tip curve calibration is started by clicking to 'Start tip curve calibration' at the Calibration page. The antenna immediately starts to move the maximum elevation angle set for the tip curve calibration. From there the radiometer performs the following steps for each elevation angle to measure. If there is no motorisation the user have to move the antenna manually to the elevation angles, which the RMC shows in the Web-Interface.

1. Wait the settling time / measurement delay
2. Take the number of samples to average
3. Store the averaged atmospheric attenuation for this elevation angle
4. Move the antenna down to the next elevation angle.

The radiometer always measures / calibrates all available channels in parallel. When the tip curve calibration has finished, the program shows a table with the measurement results instead of the normal readings page. The table shows for each channel the following parameters:

Slope	The slope of the linear regression function calculated from the measured points.
Offset	The y-axis offset of the linear regression function calculated from the measured points. (should be zero for a perfect calibrated radiometer)
Correlation	The correlation parameter gives measure of the quality of the linear regression function. A value near 1.0 should be reached.
Old Feed Loss	The feed loss used up to now
New Feed Loss	The feed loss value calculated from the tip curve.
Accept	YES/NO labels are shown for each channel in the last table row. Clicking to a label toggles it from YES to NO and vice versa. Only the calibration of channels labelled with YES gets updated when the calibration process is finished with OK.

To quit the measurement without updating any calibration values, click to "Cancel". Clicking to "OK" accepts the new feed-horn loss calibration for those channels where the results are marked with "YES".

The complete measurement results are stored as a file TIPCURVE.TXT at the radiometer's flash memory. You may download the file by entering "http://aaa.bbb.ccc.ddd/TIPCURVE.TXT" at the address bar of your favourite web browser.

After a manual Tip Curve Calibration, the user have to move the radiometer manual to the desired elevation angle.

3.5.2 Cold-Load Calibration

The cold-load calibration is used to calibrate the noise correction factor (b). in fact, this fine tunes the slope of the linear function which computes the atmospheric temperature from the radiometer raw reading.

To start a cold-load calibration, connect a cold-load to the test port of the radiometer channel to calibrate. Then, at the Calibration page select 'Switch channel 1 to cold-load' or 'Switch channel 2/3 to cold-load', depending on the channel where the cold-load is connected. This actuates the wave guide switch to the selected test port and changes the calculation of atmospheric temperature according to equation 5.16 to 5.20.

The radiometer returns to the Reading page and displays the cold-load temperature. The displayed temperature value is based on the actual calibration of the radiometer. You may now either select (ABORT) to return to normal mode (this switches the wave guide back to antenna) or (START CALIBRATION) in order to recalibrate the radiometer.

In the latter case the radiometer temporarily sets the noise correction factor (b) to 1.0 and takes the configured number of radiometer readings. From the average of these readings it calculates a new noise correction factor.

Instead of the normal reading page the radiometer shows a table presenting the nominal cold-load temperature, the measured temperature, the old noise correction factor and the new one.

Clicking to 'Cancel' abandons the calibration result, leaves the noise correction factor at it's old value. Clicking to 'OK' replaces the noise correction factor by the new one. In both cases the wave guide switch of the calibrated channel is reset to the antenna.

Please note the following:

- With a 3-channel radiometer you may either calibrate channel 1 or the channels 2 & 3 at a time.
- When calibrating channel 2 & 3, average a larger number of samples than with channel 1. This is because channel 2 & 3 are measured alternately which reduces the effective measurement rate to one measurement every two seconds.

3.6 Installation Parameters

The page 'Setup' contains the radiometer's installation parameters. Installation parameters are those which are assumed to be changed less frequently than the operational parameters on the Settings page.

The page displays a table with the parameters actually set. Each parameter value is a hyper-link to a separate page which lets you change this parameter. This parameter change page shows the actual parameter setting either in an entry field or in a drop down box. You may change the parameter to the desired value and then click to the 'Submit' button to pass the changed value to the radiometer. The radiometer automatically returns to the setup page when the parameter has been changed. To cancel a parameter modification you already started, either use the 'Back' button of you web browser or click to the 'Setup' button on navigation bar. Both returns to the setup page without changing the parameter you edited.

The table below lists the settings provided by this page.

General

Parameter Name	*Description*
Note	The radiometer's reading page by default shows the title 'Reading'. By entering a different text here, you can make the radiometer show a customised title.
Date / time	By changing this value you can set the internal clock of the radiometer. The clock is set as soon you click to the 'Submit' button in the data entry dialogue. The most precise method to set the time is to enter a time one or two minutes ahead and click to 'Submit' when this time is reached. **Remark:** Even if the radiometer is configured to use NTP to synchronise it's clock, it is important to set the time (the RTC chip) to a reasonable value. Synchronising to a NTP server sets the controllers actual time/date but never sets the RTC chip. When the radiometer starts up, it uses the RTC to initialise it's clock. This time is used until the first NTP synchronisation is done. If the RTC time is too much off, time dependent functions like logging or the sun outage may not work as expected.
Screen Refresh	The reading page by default refreshes automatically every second. The refresh rate may be slowed down, setting it to zero disables the automatic refresh completely.
NTP server IP address	To enable the NTP clock synchronisation, enter a valid IP address (aaa.bbb.ccc.ddd notation) of a NTP server accessible to the radiometer. Setting the address to 0.0.0.0 disables NTP time sync.
Communication address	The serial interface may be operated either with the MOD-95 / Miteq protocol, using a device address 'A' to 'G' or with a simple ASCII / terminal protocol (setting 'NONE'). See chapter 4.3 The RS232 remote control interface for details.
Rescom emulation port	The port for the Rescom protocol emulation over TCP/IP. To enable the emulation port enter a valid port address.

Radiometer Front-end

Parameter Name	*Description*
No. of measurement channels	This defines the type of radiometer front-end connected to the controller: 1 defined a single channel radiometer 2 defines a dual channel radiometer 3 defines a triple channel radiometer (in fact a dual channel, measuring alternately at 2 frequencies at the second channel.
Meas. frequency channel 1	The measurement frequency (GHz) of the first radiometer channel.
Meas. frequency channel 2	The measurement frequency (GHz) of the second radiometer channel.
Meas. frequency channel 3	The measurement frequency (GHz) of the third radiometer channel.

Antenna Configuration

The antenna installation parameters are defined in this section. Each parameter appear twice for azimuth and elevation respectively.

Parameter Name	*Description*
Position	With this parameter you set the type of position sensor the radiometer shall read for this axis.

sensor type	Known sensor types are: SSI-13B (13 bit binary) SSI-13G (13 bit gray code) SSI-17B (17 bit binary) SSI-17G (17 bit gray code) NONE Setting the sensor type to NONE disables any motor control for this axis.
Sense invert	With this parameter you easily can reverse the sense of a position sensor. The sense should be as follows: • Azimuth: The antenna looks more to the west for larger values. • Elevation: Larger values mean higher elevation.
Calibration offset	The calibration offset is added to the position reading before the angle value is displayed.
Calibration scale	Normally the radiometer assumes that the full range of a position sensor corresponds 360°. If you are using a multi-turn position sensor or if the position sensor is mounted to the shaft of a gear rather than to the antenna axis directly, the position sensor reading must be scaled. The displayed angle is computed as follows: *displayed-value = (raw-reading * scale) + offset* Mathematically a scale value of 1.0 disables the scaling. Beside this, the radiometer also accepts the special value 0 to disable scaling at all.
Pointing hysteresis	If a new target angle is commanded for a particular axis, the radiometer controls the antenna motor until the angle measured with the position sensor matches the target value within this hysteresis.
Upper limit	The maximum target value accepted at the user interface and via remote control. This software limit prevents the radiometer from running the antenna to the limit position under normal conditions.
Lower limit	The minimum target value accepted at the user interface and via remote control. This software limit prevents the radiometer from running the antenna to the limit position under normal conditions.

Location

Parameter Name	*Description*
Antenna latitude	The geodetic latitude of the antenna. For a precise sun outage calculation this value should be entered with 0.001° accuracy.
Antenna longitude	The geodetic longitude of the antenna. For a precise sun outage calculation this value should be entered with 0.001° accuracy.
Antenna abs. altitude	The absolute altitude over sea of the antenna location.

Voltage Monitors

Parameter Name	*Description*
Voltage monitor 1 label .. Voltage monitor 1 label	These parameters define the labels for the state of the voltage monitors 1 .. 6 displayed at the test page. These depend on the radiometer electronics used with the RMC. If you enter *n/a* for 'not applicable' as a label, this voltage monitor is not shown at the test page. A voltage monitor disabled this way is always considered to be 'OK' and not taken into account for the summary fault.

Access Control

Parameter Name	*Description*

User Password	Defines the user password (default 'user'), which is required to change any parameters from the Settings page. An empty password disables the password prompting.
Administrator Password	Defines the administrator password (default 'admin'), which is required to change any configuration or calibration settings. An empty password disables the password prompting.

4 Remote Control

The ***sat-nms*** radiometer may be controlled remotely by a monitoring and control application either through the TCP/IP interface or through a serial RS232 interface. Both communication methods use the same commands and parameters, however, there are different frames around each message depending communication method used.

Controlling the device from the web interface, the TCP/IP remote control interface or via the serial interface is completely equal, commands may sent to any interface at any time, the radiometer will use the parameter it receives last.

4.1 General command syntax

The radiometer knows a number of parameters, each identified by a parameter name. To set a certain parameter to a new value, a message:

name=value

has to be sent to the radiometer. The radiometer interprets this command, checks the range of *value*, sets the internal parameter and then answers:

name=value

The *value* in the reply is the value actually recognised by the beacon radiometer. For instance, if the requested value was out of range, the replied (and internally used) value is limited to the applicable minimum or maximum.

To read a parameter from the radiometer, instead of a new parameter value a question mark is sent:

name=?

The radiometer replies the actual value in a complete message:

name=value

A complete list of the parameter the radiometer knows is shown later in this document in chapter Parameter list. Below, some common rules applying to the remote control message syntax are summarised.

- Parameter names always are of lower case letters, most of them are four characters long.
- Non-numeric parameter values always are written in upper case.
- Numeric (floating point) values may be specified with an arbitrary precision, however the device will reply only a fixed number of places. The radiometer recognises a decimal point ('.'), numbers must not contain any commas.
- There must not be any whitespace in front or after the '=' in a message.
- If the command/query is not of the form **name=value** or **name=?**, the radiometer replies the message **?SYNTAX**.
- If the message syntax is OK, but contains an unknown parameter name is used, the reply is **? UNKNOWN**
- Numeric parameters are cut to the limits defined for this particular parameter.
- Misspelled choice values cause the radiometer to set the first value of the choice list.
- Assigning a value to a read-only parameter will cause no fault, however the radiometer will overwrite this parameter immediately or some seconds later with the actual value.

4.2 The TCP/IP remote control interface

Controlling the radiometer through the network is done by means of HTTP GET requests. Setting parameter values or querying readings or settings, all is done by requesting HTTP documents from the radiometer. The message *to* the radiometer thereby is coded into the URL as a CGI form parameter. The radiometer replies a one line document of the MIME type 'text/plain'.

The document name for remote control is **/rmt**, hence (assuming the radiometer is listening to the IP address 10.0.0.1), requesting a document with the URL

http://10.0.0.1/rmt?aat1=?

will let the radiometer reply the actual atmospheric attenuation in a one line text document:

aat1=0.42

This way all parameters may be queried or set, you may use your favourite web browser to try out the remote control of the radiometer manually.

4.3 The RS232 remote control interface

Beside the network interface, the radiometer also provides an RS232 serial port which can be used to control the device remotely. Depending on the device address set, the radiometer either runs framed protocol with start/stop characters and checksum or it provides a dumb terminal interface. The RS232 interface always operates at 9600 baud, no parity, 8 data bits, one stop bit.

If an address 'A' .. 'G' is selected, the radiometer expects each message it receives to be packed into a frame as described below.

char #	*example*	*description*
1	{	start character, always '{'
2	A	device address (A..G)
3	l	first character of the message body
.	e	message body ...
.	v	..
.	l	..
.	=	..
n-1	?	last character of the message body
n	}	end character, always '}'
n+1	.	checksum

The checksum byte is calculated using an algorithm as implemented by the following formula:

$$sum = 32 + \left(\sum_{i=1}^{n} \langle byte[i] - 32 \rangle \right) \text{ modulo } 95$$

This protocol type is known as *MOD95-* or *Miteq protocol*. The radiometer also packs it's reply in a protocol frame as described above. incomplete frames, checksum errors or address mismatches let the radiometer ignore the message. The time between the characters of a message must be less than 5 seconds or the radiometer will treat the message as incomplete.

If the radiometer is set to the device address 'NONE', it uses a simple line protocol instead of the framed protocol described above. Messages sent to the radiometer have to be terminated with a carriage return character (ASCII 13), the radiometer terminates replies with a CR/LF pair (ASCII 13/10). There is no echo for characters entered, hence this protocol easily may be used for computer based remote control.

4.4 Parameter list

The table below shows the complete list of M&C parameters the radiometer knows. For each parameter the format and a short description is given.

name		*format*	*unit*	*description*
aalt		#	m	Antenna altitude
aat1	r/o	#.##	dB	Atmospheric atten. chan 1
aat2	r/o	#.##	dB	Atmospheric atten. chan 2
aat3	r/o	#.##	dB	Atmospheric atten. chan 3
acal		#.###	°	AZ Calibration offset
addr		A,B,C,D,E,F,G,NONE		Communication address
ahys		#.###	°	AZ Pointing hysteresis
ainv		NORMAL,INVERTED		AZ Sense invert
ajog		#		Antenna jog mode
alat		#.###	°N	Antenna latitude
alon		#.###	°E	Antenna longitude

alp1		#.###		Feed weight factor (a)
alp2		#.###		Feed weight factor (a)
alp3		#.###		Feed weight factor (a)
amax		#.###	°	AZ Upper limit
amin		#.###	°	AZ Lower limit
apos	r/o	#.###	°	AZ Pointing
asca		#.######		AZ Calibration scale
asen		SENS_OPTIONS		AZ Position sensor type
atar		#.###	°	AZ Target value
atp1	r/o	#.#	K	Atmospheric temp. chan 1
atp2	r/o	#.#	K	Atmospheric temp. chan 2
atp3	r/o	#.#	K	Atmospheric temp. chan 3
bcl1		#.####		Noise correction (b)
bcl2		#.####		Noise correction (b)
bcl3		#.####		Noise correction (b)
boot		#		Reboot
csbl		OFF,ON		Case blower
dele		#		Delete target
ecal		#.###	°	EL Calibration offset
ehys		#.###	°	EL Pointing hysteresis
einv		NORMAL,INVERTED		EL Sense invert
emax		#.###	°	EL Upper limit
emin		#.###	°	EL Lower limit
epos	r/o	#.###	°	EL Pointing
esca		#.######		EL Calibration scale
esen		SENS_OPTIONS		EL Position sensor type
etar		#.###	°	EL Target value
fhba		#.#	dB/min	F/H blower rain detection
fhbm		OFF,AUTO		F/H blower mode
fhbt		#.#	°C	F/H blower temp. threshold
fhhm		OFF,AUTO		F/H heater mode
fhht		#.#	°C	F/H target temperature
flgs	r/o			Status flags
frq1		#.##	GHz	Meas. frequency channel 1
frq2		#.##	GHz	Meas. frequency channel 2
frq3		#.##	GHz	Meas. frequency channel 3
lfh1		#.####		Feed loss (L_h)
lfh2		#.####		Feed loss (L_h)
lfh3		#.####		Feed loss (L_h)
load		#		Load target
lrf1		#.###		Reflector loss (L_rfl)
lrf2		#.###		Reflector loss (L_rfl)
lrf3		#.###		Reflector loss (L_rfl)
lsyn	r/o			Last time synchronisation
lw11		#.###		Diplexer loss (L_wg1)
lw12		#.###		Diplexer loss (L_wg1)
lw13		#.###		Diplexer loss (L_wg1)
lw21		#.###		W/G & coupler loss (L_wg2)

lw22		#.###		W/G & coupler loss (L_wg2)
lw23		#.###		W/G & coupler loss (L_wg2)
lw31		#.###		Waveguide loss (L_wg3)
lw32		#.###		Waveguide loss (L_wg3)
lw33		#.###		Waveguide loss (L_wg3)
lw41		#.###		Waveguide loss (L_wg4)
lw42		#.###		Waveguide loss (L_wg4)
lw43		#.###		Waveguide loss (L_wg4)
lw51		#.###		Test port W/G loss (L_wg5)
lw52		#.###		Test port W/G loss (L_wg5)
lw53		#.###		Test port W/G loss (L_wg5)
mstp		#		Motor stop
nchs		#		No. of measurement channels
note				Note
nseq		#.######		Noise quantum
ntps				NTP server IP address
pwda				Admin password
pwdu				User password
raw1	r/o	#		Radiometer chan 1 raw value
raw2	r/o	#		Radiometer chan 2 raw value
raw3	r/o	#		Radiometer chan 3 raw value
rfbm		OFF,AUTO		RFL blower mode
rfbt		#.#	°C	RFL blower temp. threshold
rfhm		OFF,AUTO		RFL heater mode
rfht		#.#	°C	RFL min. temperature
rfhx		#.#	°C	RFL heater max. temperature
rfsh		#	sec	Screen refresh
rnt1		#.####		RX Reflection coeff. (r_ant)
rnt2		#.####		RX Reflection coeff. (r_ant)
rnt3		#.####		RX Reflection coeff. (r_ant)
save		#		Save target
scnt	r/o	#		Save count
spiv		#	sec	Sun pos. calculation interval
spwa		#.#	°	Sun pos. fault az-diff (+/-)
spwe		#.#	°	Sun pos. fault el-diff (+/-)
srno	r/o			Device serial no
stim				Date / time
suaz	r/o	#.###	°	Sun azimuth
suel	r/o	#.###	°	Sun elevation
sver	r/o			Software version
tavg		#	sec	Averaging time
tca1	r/o	#.####		T/C result slope
tca2	r/o	#.####		T/C result slope
tca3	r/o	#.####		T/C result slope
tcav		#		T/C samples to average
tcb1	r/o	#.####		T/C result offset
tcb2	r/o	#.####		T/C result offset
tcb3	r/o	#.####		T/C result offset

tcc1	r/o	#.####		T/C result correlation
tcc2	r/o	#.####		T/C result correlation
tcc3	r/o	#.####		T/C result correlation
tcdy		#	sec	T/C measurement delay
tcma		#.#	°	T/C maximum elevation
tcmi		#.#	°	T/C minimum elevation
tcnm		#		T/C number of steps
tcrv		#		Start/stop/accept tip curve
tcsk		#.#	K	Cosmic temperature
tflt		#.#	°C	Temp. diff. fault limit
tgnd		#	K	Ground temperature
time	r/o			Date / time
tipt	r/o	#.##	°C	Ref load loop I-Offset
tmd1		#	K	Media temperature
tmd2		#	K	Media temperature
tmd3		#	K	Media temperature
tpwm	r/o	#	%	Ref load pwm control
tref		#.#	°C	Ref load target temp.
trin		#.###	min	Ref load loop I-factor
trpr		#.###	%/°C	Ref load loop P-factor
ts01	r/o	#.##	°C	Temperature sensor 01
ts02	r/o	#.##	°C	Temperature sensor 02
ts03	r/o	#.##	°C	Temperature sensor 03
ts04	r/o	#.##	°C	Temperature sensor 04
ts05	r/o	#.##	°C	Temperature sensor 05
ts06	r/o	#.##	°C	Temperature sensor 06
ts07	r/o	#.##	°C	Temperature sensor 07
ts08	r/o	#.##	°C	Temperature sensor 08
ts09	r/o	#.##	°C	Temperature sensor 09
ts10	r/o	#.##	°C	Temperature sensor 10
ts11	r/o	#.##	°C	Temperature sensor 11
ts12	r/o	#.##	°C	Temperature sensor 12
ts13	r/o	#.##	°C	Temperature sensor 13
ts14	r/o	#.##	°C	Temperature sensor 14
ts15	r/o	#.##	°C	Temperature sensor 15
ts16	r/o	#.##	°C	Temperature sensor 16
ts17	r/o	#.##	°C	Temperature sensor 17
ts18	r/o	#.##	°C	Temperature sensor 18
ts19	r/o	#.##	°C	Temperature sensor 19
ts20	r/o	#.##	°C	Temperature sensor 20
ts21	r/o	#.##	°C	Temperature sensor 21
ts22	r/o	#.##	°C	Temperature sensor 22
ts23	r/o	#.##	°C	Temperature sensor 23
ts24	r/o	#.##	°C	Temperature sensor 24
wgps		OFF,ON		Waveguide pressuriser
wgs1		A,B		WG switch 1 position
wgs2		A,B		WG switch 2 position
tct1		NO,YES		T/C result accept

tct2		NO,YES		T/C result accept
tct3		NO,YES		T/C result accept
tcl1	r/o	#.####		T/C corr. feed loss (L_h)
tcl2	r/o	#.####		T/C corr. feed loss (L_h)
tcl3	r/o	#.####		T/C corr. feed loss (L_h)
ccld		#		Start/stop/accept C/L calib
clav		#		C/L samples to average
clt1		#.#	K	C/L channel 1 nominal temp.
clt2		#.#	K	C/L channel 2 nominal temp.
clt3		#.#	K	C/L channel 3 nominal temp.
clm1	r/o	#.#	K	C/L channel 1 measured temp.
clm2	r/o	#.#	K	C/L channel 2 measured temp.
clm3	r/o	#.#	K	C/L channel 3 measured temp.
clb1	r/o	#.#		Calculated noise correction (b)
clb2	r/o	#.#		Calculated noise correction (b)
clb3	r/o	#.#		Calculated noise correction (b)
tmea	r/o	#.#	°C	Ref load measured temp.
cflg		OFF,ON		Logging to CF card
pnam				Preset name
vmn1				Voltage monitor 1 label
vmn2				Voltage monitor 2 label
vmn3				Voltage monitor 3 label
vmn4				Voltage monitor 4 label
vmn5				Voltage monitor 5 label
vmn6				Voltage monitor 6 label

The status string returned with the 'flgs' command contains 28 status flags each being either '0' or '1'. '1' means the flag is active or the fault condition is true. '0' means the flag is inactive or there is no fault. Flag numbering starts with zero for the leftmost flag in the string.

no.	*description*
0	summary fault
1	voltage monitor 1 fault
2	voltage monitor 2 fault
3	voltage monitor 3 fault
4	voltage monitor 4 fault
5	voltage monitor 5 fault
6	voltage monitor 6 fault
7	peltier heater/cooler fault
8	temperature at ref load out of limits
9	pressuriser fault
10	waveguide switch 1 fault
11	waveguide switch 2 fault
12	time synchronisation fault
13	sunshine into the reflector falsifies results
14	reserved
15	avr programming fault
16	azimuth low limit switch
17	azimuth high limit switch
18	azimuth motor error

19	elevation low limit switch
20	elevation high limit switch
21	elevation motor error
22	azimuth moving
23	elevation moving
24	antenna manually controlled
25	rain detected
26	tip curve calibration in progress
27	logging to CF card failed
28	cold-load calibration in progress

4.5 FTP Download

The radiometer controller stores on the compact flash card every second the measured sky temperature from each channel (see also chapter 2.5 Format Compact Flash Card). The RMC write every day one file. This file can be downloaded with an ftp-client. But if the file from today should be loaded down the log to ftp have to be switched off.

Connect to the RMC with an ftp-client and the user name/password below in the table. Then you can download the stored files.

User Name	*Password*
service	service

4.6 FTPUpdate

You can update the radiometer controller with a special tool 'FTPUpdate' from SatService. With this tool you can also read and write the configuration.

Update

Open this tool in the folder where the update is stored. Enter the corresponding IP-address and select the device 'RMC'. Then push the button 'Start Update'. In the window you can see the actual status. When the update is done you have to reboot the RMC with the 'Reboot' button. But be careful, when you do a reset the RMC is not available over the Ethernet for a few seconds.

Read and Write Config

Open this tool in the folder where you want to read the config to or write the config from. Enter the corresponding IP-address and select the device 'RMC'. In the window you can see the actual status.

If you want to read the config from RMC press the 'Read Config' button. If you want to write the config, press the button 'Write Config'. After this you have to do reboot the RMC with the 'Reboot' button. Then the settings from the file are loaded. You have to do a reboot immediately after a write of config because the settings will be overwritten if you change something over the web interface. But be careful, when you do a reset the RMC is not available over the Ethernet for a few seconds.

4.6 Rescom Interface Protocol Emulation

The radiometer controller provides a Rescom Interface Protocol Emulator over TCP/IP. You can request the Measured Data (RM), the Housekeep Data (RH) and the System Status (RS). The radiometer controller answers to these three commands RM, RH and RS with the corresponding Rescom string. The default Port is 2101. The RMC accept only one connection at the same time.

The Rescom Interface Protocol expect a frame termination with a Checksum Character followed by a Carriage Return <CR> (ASCII 13). The Checksum Character is calculated in the following way:

- Make the Sum of the value of all the characters in the datablock modulo 96.
- Add 32 to the value and send the character corresponding to the sum. This will be a printable character.

Example:

- *RM = ASCII(82) + ASCII(77) = (159 Modulo 96) = 63 + 32 = '_'*

For the three implemented Commands the Checksum Character is the following

Frame	*Checksum*	*Type*
RM	_	Measured Data
RH	Z	Houskeep Data
RS	e	System Status

It is possible to connect to this port with a simple telnet client. To establish a connection , the following command is entered at a Command Line: *telnet 192.168.2.76 2101* (You have to enter the correct IP-Adress). Now you can type one of the three Commands with the Checksum e.g. *RM_*.

Request Measured Data RM

In a 20/30GHz Radiometer the Answer is: *M ##.##, ##.##, ##.##, #.##, #.##, #.##, 99.99, 99.99, 99.99,999.99* In a 13.5GHz Radiometer the Answer is: *M 999.99, ##.##,999.99, 99.99, ##.##, 99.99, 99.99, 99.99, 99.99,999.99*

description	*20/30GHz*	*13,5GHz*
Primary front end channel	31.7 GHz sky noise	999.99 K
Lower alternate front end channel	21.3 GHz sky noise	13.5 GHz sky noise
Upper alternate front end channel	23.8 GHz sky noise	999.99 K
Primary front end channel	31.7 GHz attenuation	99.99 dB
Lower alternate front end channel	21.3 GHz attenuation	13.5 GHz attenuation
Upper alternate front end channel	23.8 GHz attenuation	99.99 dB
Scaled calculated attenuation (dummy value)	99.99 dB	99.99 dB
Scaled calculated attenuation (dummy value)	99.99 dB	99.99 dB
Liquid and vapour phase water (dummy value)	99.99 dB	99.99 dB
Liquid and vapour phase water (dummy value)	99.99 dB	999.99 dB

Request Housekeeping Data RH

In a 20/30GHz Radiometer the Answer is: *H -50.00,-50.00, ##.##, ##.##, ##.##, ##.##,-50.00,-50.00, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##,-50.00,-50.00,-50.00*

If no temperature sensor is present, the RMC returns the value '-50.00'.

20/30GHz Radiometer description	*RMC Sensor*
30 GHz temperature cold load, internal sensor	not used
30 GHz temperature cold load, external sensor	not used
30 GHz temperature test port	06
30 GHz Noise Source temperature	02
30 GHz reference load temperature	01
30 GHz temperature regulator temperature	01
21.3/23.8 GHz temperature cold load, internal sensor	not used
21.3/23.8 GHz temperature cold load, external sensor	not used
21.3/23.8 GHz temperature test port	22
21.3/23.8 GHz Noise Source temperature	18
21.3/23.8 GHz reference load temperature	17
21.3/23.8 GHz temperature regulator temperature	17
Diplexer temperature	16
Feed horn temperature	13
Feed horn transition temperature	15
Electronics enclosure temperature	10
Antenna blower temperature	09

Antenna reflector temperature	14
Customer specific	not used
Customer specific	not used
Customer specific	not used

In a 13.5GHz the Answer is: *H -50.00,-50.00,-50.00,-50.00,-50.00,-50.00,-50.00,-50.00, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##, ##.##,-50.00,-50.00,-50.00*

If no temperature sensor is present, the RMC returns the value '-50.00'.

13.5GHz Radiometer description	*RMC Sensor*
Not used	not used
Not used	not used
Not used	not used
Not used	not used
Not used	not used
Not used	not used
13.5 GHz temperature cold load, internal sensor	not used
13.5 GHz temperature cold load, external sensor	not used
13.5 GHz temperature test port	06
13.5 GHz Noise Source temperature	02
13.5 GHz reference load temperature	01
13.5 GHz temperature regulator temperature	01
Diplexer temperature	16
Feed horn temperature	13
Feed horn transition temperature	15
Electronics enclosure temperature	10
Antenna blower temperature	09
Antenna reflector temperature	14
Customer specific	not used
Customer specific	not used
Customer specific	not used

Request System Status RS

In a 20/30GHz Radiometer the Answer is: *S 20.00, 20.00, ##.##, 6.00, #.##, #.##, #.##, #.##, 0.00*

In a 13,5GHz Radiometer the answer is: *S 20.00, 20.00, ##.##, 1.00, 9.99, 0.00, 9.99, #.##, 0.00*

description	*Value*
First Scaling Frequency in GHz	20.00
Second scaling frequency in GHz	20.00
Combined power supply status	0 = Not OK; 63 = OK
The number of primary and alternate front end channels	1 = 13.5 GHz; 6 = 20/20/30 GHz
Primary channel waveguide position (30GHz)	0.00 = the input is connected to the antenna; 1.00 = the input is connected to the Test Port; 9.99= 13.5 GHz radiometer
Alternate channel WG switch position (20GHz and 13.5 GHz)	0.0 = the input is connected to the antenna; 1.00 the input is connected to the Test Port
Primary channel IF gain (30 GHz)	2.00 = normal conditions in the IF channel; 9.99 for a 13.5 GHz radiometer
Alternate channel IF gain (20 GHz or 13.5 GHz)	always 2.00 = normal conditions in the IF channel
Radiometer front end serial	0.00

number	

5 Theory of Operation

This section gives some background information about how the ***sat-nms*** RMC works.

Chapter 5.1 Radiometer Concept describes how the ***sat-nms*** RMC measures the atmospheric attenuation and how the measurement concept works.

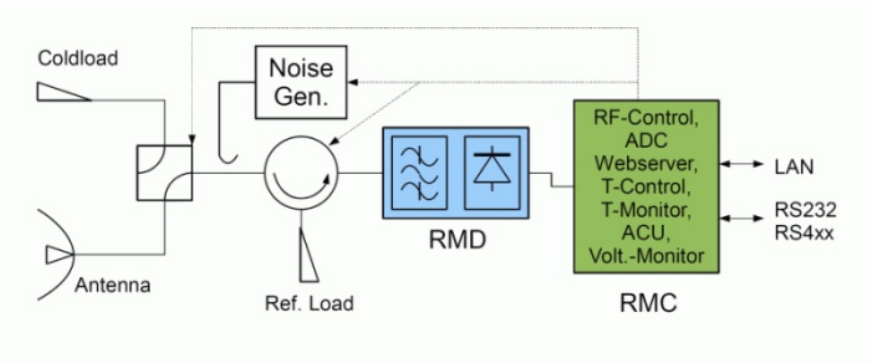
Chapter 5.2 Radiometer Calibration describes the calibration of a radiometer with the ***sat-nms*** RMC.

Chapter 5.3 Antenna Control Unit describes how the ***sat-nms*** RMC measures the antenna pointing and how it controls the motors.

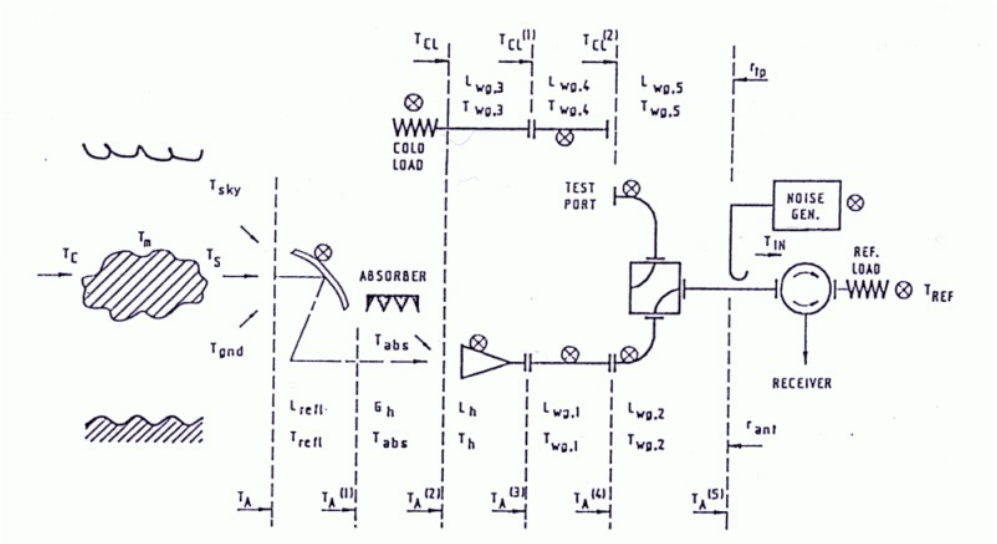
5.1 Radiometer Concept

Principle Structure

The radiometer type implemented is noise balancing / noise injection. The following diagram shows the principle structure. A circulator switches between the antenna/noise generator (noise diode) and a reference load. The following detector (RMD) rectifies the different signals. The RMC measure the signals and control the noise diode and the circulator.



Calculation of atmospheric attenuation



A noise balancing radiometer tries to reach equal noise-levels between the reference load and the noise generator (noise diode) plus the noise-level from the antenna. For this, the noise diode adds noise power to the received power from the antenna. The noise diode is pulse width modulated and a defined amount of noise power (n=Pulses; Q=Noise quantum) can be added. Equation 5.1 shows the relation.

$$T_A^{(5)} + T_{in} = T_{REF} \Rightarrow T_A^{(5)} + n \cdot Q = T_{REF} \quad (5.1)$$

With this relation in equation 5.5 we can calculate the noise power at the noise injection point. 'b' is a calibration factor for the added amount of the noise diode.

$$T_A^{(5)} = T_{REF} - n \cdot Q \cdot b \quad (5.5)$$

The receiver system is not ideal matched and a small amount of power is reflected by the antenna. For this equation 5.6 subtract the reflected power.

$$T_A^{(5)} = T_{REF} - n \cdot Q \cdot b - r_{ant} \cdot T_{REF} \quad (5.6)$$

The waveguides in the radiometer receiver are afflicted with ohmic losses and add also some noise power to the received signal. This influence is corrected with equation 5.7, 5.8, 5.9.

$$T_A^{(4)} = L_{wg,2} \cdot T_A^{(5)} - \left(L_{wg,2} - 1\right) \cdot T_{wg,2} \quad (5.7)$$

$$T_A^{(3)} = L_{wg,1} \cdot T_A^{(4)} - \left(L_{wg,1} - 1\right) \cdot T_{wg,1} \quad (5.8)$$

$$T_A^{(2)} = L_h \cdot T_A^{(3)} - \left(L_h - 1\right) \cdot T_h \quad (5.9)$$

The horn antenna is also afflicted with losses. This influence is corrected with equation 5.10. a is a weight factor for the influence of the added noise.

$$T_h = a \cdot T_{horn} + (1-a) \cdot T_{trans} \quad (5.10)$$

The horn antenna pickup some noise power because of the spillover. This influence is corrected with equation 5.11.

$$T_A^{(1)} = \frac{T_A^{(2)} - G_h \cdot T_{abs}}{1 - G_h} \quad (5.11)$$

Also the reflector is afflicted with losses. This influence is corrected with equation 5.12.

$$T_A = L_{rfl} \cdot T_A^{(1)} - \left(L_{rfl} - 1\right) \cdot T_{rfl} \quad (5.12)$$

At low elevation angles the antenna pickup noise from the ground. The amount depends on the elevation angle theta. Equation 5.13 corrects the influence and calculates the “real” sky noise.

$$T_{sky} = \frac{T_A - T_{gnd} \cdot G_p(\Theta)}{1 - G_p(\Theta)} \quad (5.13)$$

Finally, the atmospheric attenuation can be calculated with equation 5.14.

$$\boxed{A = \frac{T_M - T_{clearsky}}{T_M - T_{sky}} \Rightarrow a_{atm} = 10 \cdot \log\left(\frac{T_M - T_{clearsky}}{T_M - T_{sky}}\right)[dB]} \quad (5.14)$$

5.2 Radiometer Calibration

5.2.1 Cold-load Calibration

Noise power from noise diodes fluctuate from diode to diode. Also the decouple factor of the coupler fluctuate. This deviation is determined during a cold-load calibration and the absolute base is set.

A cold-load is a waveguide termination insight an isolated box. Liquid nitrogen cools the termination to approximately 80K (-193°C). This is a stable noise source and the variations in noise power are very small. Equation 5.15 shows the calculation of the correction factor 'b'.

$$\boxed{b = \frac{T_{ref} - T_{CL}}{T_{ref} - T_{mess}}} \quad (5.15)$$

The noise power of a cold-load 'T_CL' is deposited in a calibration certificate. 'T_mess' is the measured noise temperature of the cold-load. This value has to be corrected with the following equations. Equation 5.16 shows the basic calculation.

$$T_A^{(5)} = T_{REF} - n \cdot Q \cdot b \quad (5.16)$$

The reflected power of the mismatched receiver is subtracted with 5.17.

$$T_A^{(5)} = T_{REF} - n \cdot Q \cdot b - r_{tp} \cdot T_{REF} \quad (5.17)$$

The waveguides are also afflicted with ohmic losses. Equations 5.18, 5.19, 5.10 correct this influence.

$$T_{CL}^{(2)} = L_{wg,5} \cdot T_A^{(5)} - \left(L_{wg,5} - 1\right) \cdot T_{wg,5} \quad (5.18)$$

$$T_{CL}^{(1)} = L_{wg,4} \cdot T_{CL}^{(2)} - \left(L_{wg,4} - 1\right) \cdot T_{wg,4} \quad (5.19)$$

Finally the displayed value is calculated with equation 5.20.

$$T_{mess} = L_{wg,3} \cdot T_{CL}^{(1)} - \left(L_{wg,3} - 1\right) \cdot T_{wg,3} \quad (5.20)$$

The RMC set the factor b=1 for a calibration, so that the natural value is measured. The RMC calculate the factor 'b' automatically.

5.2.2 Tip-Curve calibration

A radiometer system is calibrated with a tip-curve. This is a standard procedure by the on-site installation and the calibration can be checked periodically. For this procedure the elevation angle have to be well know (better than 0,5°).

A tip-curve should only be conducted under clear sky conditions, because the atmosphere is reliable homogeneous. The antenna moves from zenith (theta=90°) in direction to the earth (theta=0°). Every few degrees the atmospheric attenuation is measured. In the zenith the attenuation a_z is the smallest, because the way through the atmosphere is the shortest.

The attenuation follows a secant law as show in the following equation.

$$a\left(\Theta\right) = \frac{a_Z}{\sin\left(\Theta\right)}$$

For an easier analysis of the results, the elevation angles are linearised with equation 5.21.

$$\Theta' = \frac{1}{\sin\left(\Theta\right)} \quad (5.21)$$

The conclusion is a straight as described in equation 5.22.

$$a\left(\Theta'\right) = d \cdot \Theta' + e \quad (5.22)$$

A tip-curve should only be conducted under clear sky conditions, because the atmosphere is reliable homogeneous. The antenna moves from zenith (theta=90°) in direction to the earth (theta=0°). Every few degrees the atmospheric attenuation is measured. In the zenith the attenuation is the smallest, because the way through the atmosphere is the shortest.

A best fit line is calculated from the measuring points. The standard deviation and of the points and the intersection with the y-axis is also calculated.

If the radiometer system is calibrated, the line intersects the y-axis at the 0dB point. If this is not the reason, the loss of the horn has to be corrected with the factor c from equation 5.27.

$$c = 10^{\frac{a(0)}{10}} \quad (5.27)$$

5.3 Antenna Control Unit

The ***sat-nms*** RMC provide a antenna control unit (ACU) to control a motorised radiometer. Movement in azimuth and elevation are possible, if present.

5.3.1 Position sensor types

The ***sat-nms*** RMC provides an interface for SSI type digital position encoders. These encoders are precise, reliable and provide a standardised interface. The RMC supports types with 13bit and 17bit resolution, both, gray coded and binary variants. The RMC provides 5V and 24V supply voltages (200mA max) for the encoders, so external power supplies may be omitted in most cases.

5.3.2 Angle calibration

>From the user's point of view, the RMC accepts and displays pointing angles as floating point numbers with 0.001° resolution. Internally the software treats angles as 32 bit integer numbers where the full 32 bit range corresponds to 360°. This is equivalent to a resolution of 0.000000084°.

When the software calculates the pointing angles from the sensor readings, it includes some calibration parameters configurable at the Setup page. The steps of calculating a pointing angle are as follows:

1. Get the raw value.
2. Extend (left shift) the value to 32 bits.
3. Reverse the sign if this option is set in the setup.
4. If the calibration scale is nonzero, convert the value to floating point, multiply by the calibration scale and convert the value back to 32 bit integer.
5. Add the calibration offset.
6. For the azimuth axis add the antenna course, too.

The integer value calculated this way is used for the internal pointing routines. At the user interface and for remote control, show the internal value multiplied by (36/2^32).

5.3.3 Pointing/Motor Control

The ***sat-nms*** RMC performs the pointing / motor control as a closed control loop, independently for each axis. If the measured position value differs from the target value, the motor is activated to compensate this difference. It makes no difference if a new target value has been commanded or if the antenna has moved a little bit due to a squall.

Hysteresis

To avoid that the motor is switched forth and back all the time, the ACU tolerates small differences between measured and target value within a hysteresis value. This hysteresis is individually configurable for each axis at the Setup page. To ensure that the motor stands still when the target position is reached, twice the resolution (step size) of the position sensor / encoder must be set. Common values are:

bit resolution	*angular resolution*	*recommended hysteresis*
13 bit	0.044°	0.090°
16 bit	0.005°	0.012°
17 bit	0.003°	0.006°

If the motor control loop still oscillates with the recommended hysteresis values, this is due to the off-carriage of the antenna drive. Either turn down the motor speed at the motor driver unit or enlarge the hysteresis value in this case.

Motor drive signals

The ***sat-nms*** RMC provides a number of output signals to control a motor driver unit. These signals (they are available for all two axes) are:

FWD	This signal switches the motor on for the forward direction.
REV	This signal switches the motor on for the reverse direction.
FAULT	The RMC monitors this signal all the time. The signal is high active, i.e. the RMC expects no current flowing through the optocoupler while teh the drive is OK. If the circuit is closed, the RMC signals a fault and stops the motor.

Very important is how the direction of movement is wired. The proper direction depends on if the antenna is operated on the northern or on the southern hemisphere:

axis	*northern hemisphere*	*southern hemisphere*
azimuth	FWD moves the antenna to the right (westward).	FWD moves the antenna to the left (westward).
elevation	FWD moves the antenna up	FWD moves the antenna up

Look 'through the antenna' to the sky for the correct orientation of the left/right/clockwise directions. The sense of the position sensors **must** set that the sensors give increasing values while the antenna moves FWD.

6 Specifications

6.1 *sat-nms* RMC

Technical Specification

bit resolution	*recommended hysteresis*
Temperature measurement range	0K…308K
Radiometer type implemented	Noise balancing, Noise injection
Integration time constant	1s…60s
Number of radiometers to be controlled simultaneously	2
Number of frequency selectable	2 (in one of the two radiometers)
Switching rate circulator	256HZ
Measurement resolution	Range/2048 = 0,15K
Feed / Reflector blower control	Within Software
RX-Control (circulator, LO)	TTL-Compatible output (0V…5V)
Noise Diode Control	Selectable over an external voltage. Input max +36V. Maximal output voltage +28V
Analog Input Voltage for radiometer ADC	0V…5V
Temperature regulation for feed / waveguide box integrated	Within Software
Position Encoding	SSI digital interface for Azimuth and Elevation; Quantisation Error: 13bit 0.044°, 17bit 0.0028°; Display Position resolution: 0,001°
Antenna Control Unit	Direction commands and end switches over free floating optocouplers; End switches for Azimuth and Elevation
Temperature Measurement Points	24; NTC-Resistors with 30K/25°C
Voltage Monitor	For +24V, +28V, +12V/+15V, +48V/+24V, -12V/-15V, +5V
Data logging	Compact Flash Card with 2GB for more than 2 years
Motor driver interface for frequency inverter, DC servos etc.	Via optocoupler input and output, low and high speed selectable

M&C Interface Specification

Ethernet interface for M&C and user interface	10-Base-T, Via http GET requests
RS232/RS485/422 M&C Interface	Mini Combicon MCV1

Electrical and Mechanical Specification, Environmental Conditions

Supply Voltage	24V DC 500mA
Temperature range Humidity	5° to 50° C up to 90% non condensation
DIN rail module	270x165x70mm; 1,4kg

6.2 *sat-nms* RMD

Technical Specification

Input frequency range	50…2000MHz
Internal bandpass filter for measurement	70MHz centre, 40MHz bandwidth
External filter for measurement	Any bandwidth in frequency range
Connectors IF in, DC out, external Filters	SMA female 50Ohm

Input noise figure	<10dB
Coupling input to output test-port	35dB
Input level measurement range	-128…-118dBm/Hz
Analog output voltage range	0V…5V
Temperature Sensor	Internal NTC-Resistor; 30k/25°C

Electrical and Mechanical Specification, Environmental Conditions

Supply Voltage	12…24V DC 550mA
Temperature range Humidity	5° to 50° C up to 90% non condensation
DIN rail module	110x74x30mm; 0,2kg